ENGINEERING

RIAL HIGHWAYMEN
P MINERAL WEALTH

CKET ACCELERATORS
R HIGH ENERGIES

ok Review
EVELOPING THE FRINGES
THE ARCTIC

NETRANTS FOR
N-DESTRUCTIVE TESTING

RCRAFT FLUTTER
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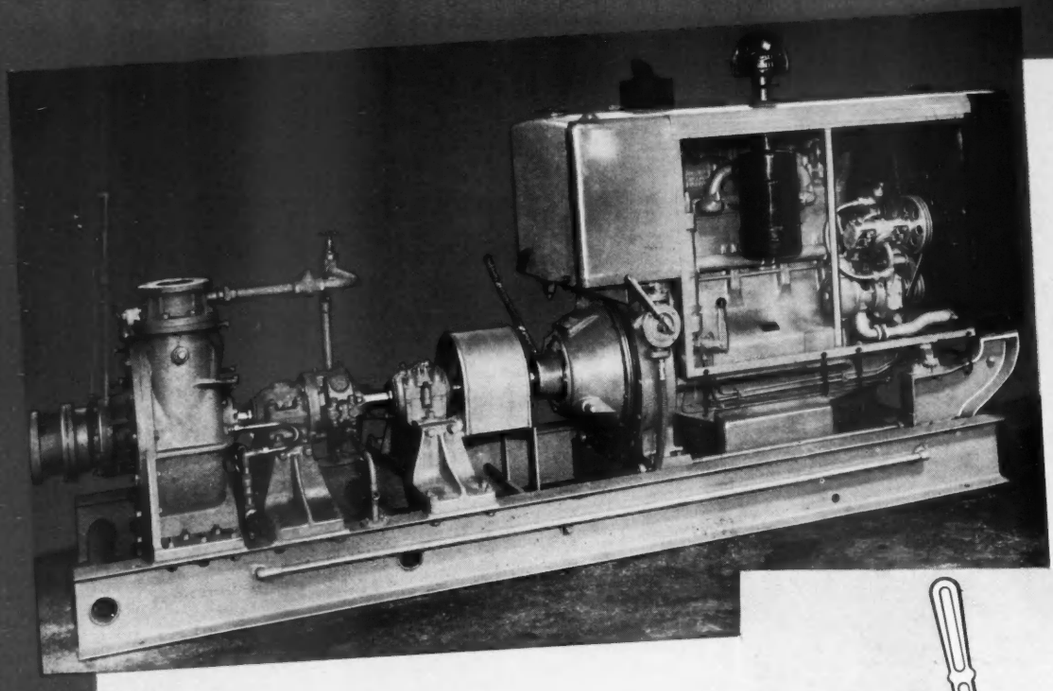

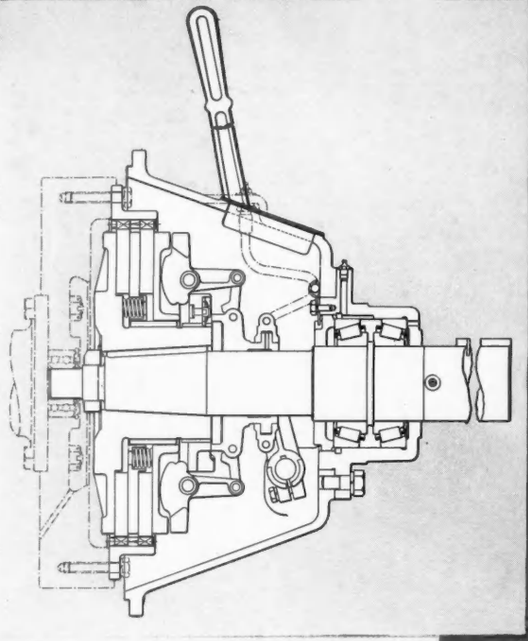

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CLUTCHES AND POWER TAKE-OFFS

ENGINEERING

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ENGINEERING *Appointments Section faces page 508*

A Future for British Shipping

A GLEAM of hope at the end of the tunnel was bravely kept before us by Sir Winston Churchill in the worst days of the Second World War. For British shipping, with the air lines arguing over the next fare cuts and more tonnage being built this year than the nine million tons laid up, it is hard to see a gleam anywhere.

But trade battles, like any others, are susceptible to ideas. While world shipping, experiences a depression, described by Sir Nicholas Cayzer, president of the United Kingdom Chamber of Shipping, as "the worst in living memory," there is for the British interest, if not a gleam at the end of the tunnel, at least a spark of hope.

Or rather two sparks.

The flexible barge, the Dracone, and the channel-crossing hovercraft. Both are British inventions or developments. Both are particularly significant for cargo delivery in a world where more and more trade goes into developing countries as yet unequipped with full scale docks. The future possibilities of the really large cargo carrying hovercraft passing from the sea far inland in Africa and Asia are plainly considerable.

As symbols of alertness to problems, both Dracone and hovercraft show the way in which British shipping, by aiming to be "one jump ahead", can stay on the seas of a world where government obstructions show no sign of abating.

The crude, first sight, view taken of British shipping is that of an industry in decline. Most often quoted is the comparison that just before the First World War our merchant fleet was 40 per cent of the world total, while in 1958 it had dropped to 17 per cent.

If this is an accusation it implies that in a developing world Britain should have kept the lead she obtained by becoming industrialised before many other countries had even begun to move out of the bare subsistence phase. In fact the British merchant fleet of 1958 was 5 per cent up on its 1914 size, an indication not of an absolute falling back but certainly a measure of the way in which world fleets and to some degree expansion of world trade had gone ahead without us.

It is of some significance that two countries of very high prosperity have actually moved away from merchant marine operations. According to the recent PEP report on the British shipping industry, the German merchant fleet of 1958 was 74 per cent of her 1914 tonnage, while Canada, faced with the same high cost difficulties that the United States Government so assiduously overcomes for its own operators, has moved out of the field of merchant shipping.

Remembering the protectionist policies for shipping applied in our own past, it is not reasonable, and certainly not in accord with the facts, to expect any early easing of the obstacles placed in the way of full, free shipping operations by the cheapest and most efficient shippers. For the newly rising nations there is an obvious attraction for a variety of reasons in running their own ships—at the expense of their own taxpayer and our traditional shipping concerns.

They have the blatant example of the United States reserving all trade between its own ports for American ships and an effective 60 per cent of all American aid cargoes, including cargoes financed even by quasi-government bodies and the Import-Export Bank. President Eisenhower, it is true, has said that the 1936 Merchant Marine Act, which enables his country to keep up an otherwise uneconomic fleet of 23 million tons (14 million in "mothballs" on the Hudson and other rivers) should be looked at again as to whether it is adequate or necessary. The result of an inquiry into the whole American transport system, shipping included, by Eisenhower-appointed independent experts, is awaited about the turn of the year. But it will be remembered that this report is to go to a President for whom the last period of his rule is running out.

Overall, as nationalism surges forward, the prospect of an increasing number of countries operating their own ships seems almost certain. Against this simple fact, and for other reasons, it appears that passionate argument over flags of convenience is not an exercise that will bring benefit or reward to shipping firms, though it is more understandable that the seafarers themselves should fight to ensure that in times even more difficult than the present their shipboard standards are not depressed.

If the future appears to be one of more hazardous waters for the shipowner the same does not follow for the shipbuilder. It is many times easier for a Ghana or a Portugal to buy a ship for its own operation than for the same country to set up its own shipyard. The British Government with its tax concessions for new ships has helped both builders and operators more, one suspects, than it will be able to in its representations against overseas versions of our one-time Navigation Acts.

It may be that for all their falling orders and present difficulties the shipyards will find enterprise and efficiency more certainly rewarded than will their sea-going brothers.

Cover Picture.—*The photograph is of a caesium-137 gamma ray therapy unit, designed and built in the workshops of Cambridge University engineering laboratories for Addenbrookes Hospital, Cambridge. It is the first of its type in this country to incorporate both fixed field and arc therapy.*

(*Nurnberg photograph for* ENGINEERING)

Plain Words

In the engineering profession I detect a kind of caste system developing. There are many people, officially called technicians, whose status is ambiguous, whereas the distinction between a professional chartered engineer and a shop floor operative is clear enough. For one reason or another technicians haven't made the grade to corporate membership of one of the senior institutions. I suspect that as a nation we don't always get the best out of them precisely because we have given them this second-best position.

In the military services there are good historical reasons for having "officers and other ranks." Officers were formerly drawn wholly from an upper social class and there was little or no promotion from the ranks. For the sake of military discipline it is necessary to preserve this distinction today even though promotion from the ranks is now general. But is there any reason why the same separateness should be perpetuated in engineering? The distinction between a commissioned officer and a warrant officer is clear-cut and is enshrined in regulations which are independent of the efficiency and quality of the individual. I would not like to distinguish so precisely between professional engineers and technicians.

To call it a caste system is, I know, to use words that are perhaps too strong, but I do so deliberately because I have found uneasiness in the profession about present tendencies. A university education is open to most young men today if they want to become engineers and if they reach a reasonable educational standard. Thus the time is near when the institutions can recruit very largely from among graduates, barring the road to anyone who has come up the hard way. Many middle-aged and older chartered engineers who are well established today came up this way themselves. Many of them hold firmly to their conviction that a university education often produces engineers who expect the world to fall into their laps, and that a boy who goes from school to a works during the day and technical college during the evening, often enters the profession with his feet pretty firmly on the ground. Of course, this is not even commonly true, but there is enough truth in it to justify a strong plea—a plea that all who have any say in these matters will leave the door open to all comers, and judge them on their merits. Engineering has never been a closed profession in this country, so let us ensure that there is always room for engineers with varieties of background.

Is the solution to have one, or perhaps two, levels between chartered institution member and craft union member?

CAPRICORN

Weekly Survey

Boom with Qualifications

Much of the picture of British industrial success is admirable. October exports hit the record of £306 million; the trade gap, even after the rise in import costs to meet the needs of expanding production, fell sharply, We are plainly building another considerable surplus.

A closer focus on the general figures finds the aircraft industry sending out exports worth £121,300,000 in the first three-quarters of the year, an increase of 7 per cent over last year in the same period. Aircraft and spare parts fell in value but the steeply rising aero-engine earnings more than took care of that. In closer detail still, Rolls-Royce are selling to the world more engines than all its competitors taken together. Of the 1,454 jet and turboprop airliners on order or in service in the Western world 56 per cent have, or will have, engines by Rolls-Royce.

There is another side to the picture. The Export-Import Bank is granting $20 million (£7·14 million) to Sabena, the Belgian airline, to buy five Boeing 707 jets. British Railways are starting a £6 million diesel-electric locomotive building programme, but the Finnish State Railways are testing one from Western Germany; they have already tried types from Sweden and Austria, but not one from this country—nor, apparently, from the Soviet Union.

From Ghana there is news that before the end of the year two Soviet consultants will arrive there to investigate the possibility of operating an iron and steel plant. There has already been some discussion on this between the two governments. On the credit side, Pye are sending a television team to Liberia where they will cover the inauguration of President Tubman in January. It is likely that Pye will later supply Liberia with a permanent television station.

The wealth-creating potential of a steel works in Ghana is a great many times that of a television station in Liberia. British industry cannot operate everywhere in the world or be in on every contract but there are still areas where greater effort and imagination would pay off.

How Much Would You Like?

Just as a feature of the largest industrial groups has been their ability to finance heavy capital re-equipment from their own resources, a distinctive mark of the small company, not in this country alone, has been its dependence on outside money. The overdraft is as familiar in the pattern of the smaller firm as it is in the habits of the banks' individual clients. Since the banks review overdrafts once or more each year this could not be the ideal way of carrying on business.

Now the Midland Bank, and simultaneously the Clydesdale and North of Scotland, announce a scheme for granting term loans to suitable industrial and commercial companies. The Radcliffe Committee recommended that banks should provide some alternative to running overdrafts for small businesses and this is evidently it.

What is not immediately clear is what would happen to term loans if another credit squeeze was suddenly handed down from the heights of the Treasury. If it simply meant that no more term loans were available for a time, then the present step is of unqualified assistance; if the loans could be influenced by "the national situation" then we are not much further forward than with the climatically sensitive overdraft.

Leaving aside such unpleasant thoughts the advantage of the term loan, which carries a 1 per cent greater interest charge, is that it is not recallable, provided repayments and interest are forthcoming, before the end of the term. The overdraft is of course legally repayable at the bank's call. Terms of up to three or five years are envisaged for plant and equipment, up to ten years for premises.

The economic future rests with the smaller firm as well as the giants, and they had to start somewhere. The new scheme should enable that part to be played without recourse to sources of money at the highest rates.

D for Decimal Day

South Africa is now legally and constitutionally on the way to a decimal coinage, New Zealand's government inquiry recommends in favour of the decimal system, both retaining the pound, and the report is being written of the inquiry into the subject in this country by the British Association for the Advancement of Science and the Association of British Chambers of Commerce.

In South Africa the 10*s* cent system will apply from 14 February, 1961. The existing 10*s* note, subdivided into ten single shillings or 100 cents is at the centre of the calculation. With the present bank notes retained only the pence will be converted.

The New Zealand recommendations also favour a 10*s* unit. The report raises the interesting side effect that rounding off fractions would produce a rise of 9*d* a week for each household in the consumer price index. What strength this might have round the wage bargaining table will have to be tested, but fractions can be rounded off in two directions. These developments leave the United Kingdom more and more isolated in a world where already 145 countries are on metric currencies.

If the predicted New Zealand figures are any guide the cost of conversion here would not be as great as has often been suggested. Most immediately affected, leaving aside the school children, would be the manufacturers of office accounting machines. The industry, already working close to capacity, would face a difficult transitional period with very large numbers of conversions and perhaps sharp extra demand as office managers decided old equipment was not worth converting and should be replaced with new.

The further the automatic vending movement progresses before the change overtakes this country the greater will be the number of machines and auto-shops needing conversion. It is worth noting here that if the report on this question in Britain comes down in favour of making the change in the immediate future, the vital factor of length of breathing space has been set at three and a half years in New Zealand.

How long the rest of the country could hold out here before going metric in measurement is a nice point for speculation; there are hardly likely to be any new arguments to be brought to bear. An important breach in the wall has taken place with the City of London's foreign exchange market. Quotations between banks on dealing rates have been conducted in decimal terms for some months.

Not so Vacant

The newly formed Joint British Committee for Vacuum Science and Technology starts its life with ten learned bodies represented round its table. For some time the need has existed for such an organisation as the new committee, to meet the interests of scientists and engineers in metallurgy, petroleum research, electronics and thermonuclear investigations; to name only a few of the fields where high vacua are employed.

A secretariat for the committee is being provided by the Institute of Physics and its

headquarters are up among the ambassadors in Belgrave Square. Liaison and arranging meetings in this country will be carried on and contact is to be maintained with the international organisation for vacuum science and technology and with other national societies.

The roll of organisations forming the British committee comprises the Institutions of Mechanical Engineers, Electrical Engineers, and Chemical Engineers, the Royal Institute of Chemistry, the Institutes of Biology, Iron and Steel, Metals, Petroleum and Physics, and the Physical Society.

Blind them with Motorways

With all the din of publicity for the motorway, and the rattle of partly irrelevant argument about bridges, it is prudent to consider what is being hidden from public view.

Doing the most obvious and expensive thing is often the least costly in mental effort by those responsible and most costly in diversion of means from achievable ends.

In the House of Lords Earl Ferrers very pertinently asked why practically every road improvement in Norfolk ended short before a bad bend, and most of the improvements themselves had a bend built in. Even the bus stops were mostly on bends. Lord Wise, in the same debate, asked what the Government were going to do for the traffic thrown on to the roads by the closing of railway lines in Lincolnshire and north Norfolk, and what was to be done for rural, industrial and holiday traffic in Norfolk generally. Lord Amwell repeated the well-known point that it is not much good motorists tearing away down motorways if the growing congestion at either end robs them of the minutes they have gained in the risky process.

Whether at a snail's pace or not, some work to relieve inner-city congestion is being done. The most recent announcement is from the London County Council who have submitted to the Minister of Transport, Mr. Ernest Marples, road schemes costing £17 million. The sting to all this is in the tail. The congestion and the delays are becoming worse now. The programme submitted to the Minister is for works to be started between next year and 1965.

Until this country is covered with an area of motorways large enough to make a significant reduction in the agricultural acreage, most of the traffic, and especially of industry, will still spend most of its time on non-special roads. This being so, no amount of propaganda, Government or private, will hide the fact that until much more is done in the built-up areas and for all classes of roads, the traffic situation will be getting worse and not better.

European Manoeuvres

The humble art of translation looms larger and larger not only in international politics but in trade. When Finland made early moves to come into the Outer Seven group, Mr. Mikoyan (the economic right hand man to first Stalin and now Khrushchev) thundered away about "remnants of the cold war." Now a full and accurate translation of what the Russian trade chief said has been in circulation and hopes are very much stronger that Finland will eventually join the trade agreement.

Earlier this month the drafting of the agreement for the Seven was completed in Stockholm. Difficulties remain over textiles, which could sweep through the quality market in Britain, and over the export from Sweden and Norway of frozen fillets and other foodstuffs. The root of the trouble here seems to be that the Scandinavians are better equipped in their fish-preparing industry than ourselves.

The full terms are now expected to be known at the turn of the year and no breakdown, in what has been an extremely rapid piece of negotiation, is now expected. But for the participating countries the benefits are going to be those which can be produced within the grouping. Early hopes that the existence of the Seven would lead to a smooth agreement with the much more powerful Six, thus re-uniting Europe, have foundered as the Six gather momentum. Herr Muller-Armack, West German secretary of state, has proposed closer coordination of economic policies in the Common Market, and Professor Hallstein, President of the Commission of the Common Market has, of course, received a favourable response to his suggestion that the transition period be shortened.

Of his proposals to start again the movement towards a European Free Trade Area the most important was the reciprocal abolition of all quotas on industrial goods from countries outside the Six. Professor Hallstein's full five-point plan, which included cooperation with other economic groups in aiding the under-developed countries, was discussed by a special committee which is reporting to the Ministers of the European Community this month.

While the future engages much of the thinking in Europe and its groups and communities, the present demands attention as some Common Market countries, notably Western Germany, show signs of moving into inflation, while others still have under-employment.

Output in the Six went on rising this year—industrial production in the last quarter of the year is expected to be about 7 per cent up on last year's figure—but the Commission advises that if the overall labour force were better used and excess reserves of expansion were directed to other member-countries then the rate of expansion would be even higher.

If this re-direction were to take the form of avoiding the building up of favourable balances of payment with non-member countries its effect on world trade outside the Common Market would be retrograde.

Cooperative Exchange

Remarkable cooperation between five manufacturing companies and a Government department took place during the design of a prototype electronic exchange at Dollis Hill. The development was initiated with a new form of contract between the GPO and five firms, in which all patents, royalties, and experience were shared.

The way to cooperative research was opened in 1956 when the Joint Electronic Research Committee (JERC) was set up. This contains representatives of the GPO, Automatic Telephone and Electric Company Limited, Ericsson Telephones Limited, General Electric Company Limited, Siemens Edison Swan Limited, and Standard Telephones and Cables Limited.

The GPO decided what the exchange had to do, but the general lines of system design were worked out by a seven-man committee, the GPO having two members on it. The committee, in turn, allocated the development of different aspects of the exchange to firms or groups of firms. The development of magnetic drum equipment, for example, was a cooperative effort between ST & C and ATE. In addition, there have been various coordinating panels: for example, one for equipment design, another investigating the repercussions of the exchange design on the subscriber's telephone instrument, another concentrating on transmission problems through the exchange. Generally, though not always, the panels had a GPO chairman. All panels reported back to JERC.

How do people working on the project view the cooperation? Here are some comments made by a GPO engineer who worked on the system design committee and the equipment design panel. "Once the basis for cooperation was laid down we all worked very well together. The cooperation is something we have never had before. But it might have been better if an autonomous organisation with separate offices had been set up: in some respects our work was made more difficult by the fact that members were scattered about the country—of course, it's in situations like that that the telephone comes into its own."

Letters to the Editor

TIME AT SCHOOL AND UNIVERSITY

SIR, Your editorial of 6 November, suggesting that three years for the university education of engineers and scientists is not enough, is, I think, most timely. To many of us the strict limitation to three years for a first degree standard, when this standard itself has been steadily rising, has seemed to put our system of education at an increasing disadvantage compared with the corresponding arrangements in Europe, and has been, at least in part, responsible for the complaint that engineers and scientists are limited in outlook, cannot write decent English, and so on.

In the course of your article you refer to the burden on "hard pressed sixth formers"; here to my mind is one of the keys to the problem. I suggest we have increasingly caused specialisation in the schools because more and more had to be crammed in to the three years allowed for university education. In consequence, specialisation in sixth forms for intending scientists and engineers has become excessive and has left very little time for the broad treatment of humanistic subjects which should be done at school.

Hence my own view is that we should re-model not only the university courses but the late years at school. This would undoubtedly lead to a four-year university course, but it should also necessitate less specialisation in the sixth form, and much more time for broad non-specialised studies which can be of such value later in life when the emphasis comes more and more on the clear communication of ideas.

Yours faithfully,
N. E. ROWE, Director.

Blackburn Aircraft Limited,
Brough, Yorkshire.
10 November, 1959.

ENGINEERS' EARNINGS

SIR, I was very interested to read your article on the subject of "What Engineers Earn" (ENGNG., 16 Oct. '59, p. 341).

The information given therein is most valuable and particularly well presented. I feel, however, that, when quoting overseas salaries for purposes of comparison, it is almost essential to couple this with some weighting factor which will take care of the widely different purchasing power of the pound in, say, America or Australia. Not only the so-called cost of living in its more fundamental aspects must be considered but also taxes, direct and indirect, difficulties of housing, schools, the kind of life one may be expected to live, health and dental schemes, hospitalisation: all these must be taken into account in assessing the real value of what may appear at first sight to be a high salary.

Although I cannot speak at first hand about the "real" value of £2,000 in America I can do so with regard to that sum in Australia. I would say that £A2,000 per annum spent in Australia would be equivalent to having £1,400 per annum to spend over here at a very optimistic assessment. For instance, in Australia, one could easily spend £3,500 on a lightly constructed poorly fitted wooden house having no cellar and needing frequent painting and maintenance; and one would perhaps be obliged to run a car to get to work owing to one's location. Here, one could at least buy a fairly solid brick-built well-fitted 2-3 bedroomed house for that money.

Nevertheless, your article reveals the harsh truth about engineers' salaries today. They are in no way related to the equivalent pre-war salaries. In my own case, for example, I had more purchasing power on £480 a year in 1936 than I shall probably ever have again, though I am now earning three times the number of pound notes.

I am, Sir,
Yours faithfully,
L. MACQUISTEN WALLACE.

Naval and Military Club,
9 November, 1959.

Continued on next page

FLEXIBLE COUPLING

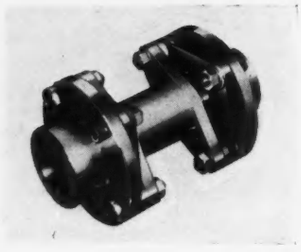
Torsional Rigidity

TURBOFLEX flexible couplings will take up to 4° of angular misalignment when fitted with a spacer as illustrated.

The units are made in sizes to transmit up to 0·3 h.p. per r.p.m. They consist of a boss coupled by the flexible element to a second boss directly or through a spacer and a second element. Without the spacer the maximum misalignment is 2°. With the spacer, axial deflections up to 0·38 in and radial misalignments up to 0·22 in are possible.

The flexible element is made up of four stacks of thin laminations of hard stainless steel. These are arranged in the form of a square and the driving and driven bosses are connected to alternate corners.

The elements are also available as separate units with the four holes bushed and machined to close limits. Each link is supported at the ends by a number of short blades so as to reduce the concentrated bending stress when the coupling is operating with a large angular misalignment.



Driving and driven bolt holes are set on a common radius which is said to reduce the cyclic stresses induced by misalignment. It is also claimed that the links are rigid torsionally and so backlash is almost eliminated and shock loads reduced. As a result the coupling is suitable for on-load starting. The absence of rolling or sliding faces eliminates the need for lubrication.

Ten sizes of coupling are made ranging from 0·001 h.p. per r.p.m. up to 0·3 h.p. per r.p.m. Shaft sizes go from ¾ in to 5 in and boss drilling allows some overlap. *Turbomachines Limited, Station Road, Dorking, Surrey.*

WORK CLAMP

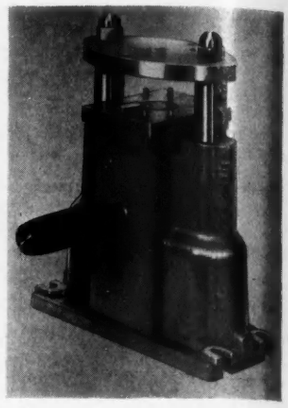
Air Operated

TWO air operated work clamps made by Fein are now available in this country. The larger size is illustrated.

Particular claims for these tools are the speed of operation and one handle control. The top clamping plate can be used as a drilling jig by making the required bushed holes. In the larger size, the DSV60, the clearance allows for a workpiece 4½ in high and 4 in between the columns. The DSV30 has the clamping columns arranged both at one side, but will only give an opening 2½ in in height. Maximum clamping forces are 90 and 200 lb respectively for an air pressure of 85 lb per sq. in.

The single control lever below the handle controls both opening and closing of the clamp, and in the case of the DSV60 also operates a swarf blower for cleaning the surfaces. As the weights are 37 and 13 lb, the clamps are easy to handle.

Changing the table and clamping plate is a simple matter so the clamps can be used for a wide variety of work. They



are steadied in position by one hand while the other is free to operate the machine tool. The steadying hand can also operate the control lever. The clamps can be operated by unskilled labour without fatigue. *Verrolec Limited, 721 North Circular Road, Cricklewood, London, NW2.*

In the note describing the Fielden Bikini temperature controller, the permissible length of cable between the measuring element and the controller was wrongly quoted. The correct figure is 300 ft which is longer than is normally possible with the filled system type of controller.

Continuing Letters to the Editor

AXLE FATIGUE TESTS

SIR, May I refer to the letter by Dr. C. E. Phillips (ENGNG, 23 Oct. '59, p. 367), commenting on your article " Central Laboratory for London Transport "?

The information regarding the axle fatigue testing machine to be installed in London Transport's new Central Laboratory was not intended to imply that there was no other machine in Great Britain capable of testing full size railway car axles, although so far as we are aware there is only one other, that being the equipment at the National Engineering Laboratory. In the course of visits by our engineers and scientific staff to East Kilbride, we have, as Dr. Phillips says, had the opportunity of seeing the equipment in use there, and there have also been valuable discussions between us on the subject of axle fatigue failures.

The machine which is being constructed for London Transport at Nottingham University is specifically designed to facilitate studies of alternative techniques for cold rolling of wheel seats on axles and to investigate the concentration of stresses introduced by the cold rolling process. Because of the nature of the problem to be investigated, it was considered advisable to use different methods of support and excitation for the specimen from that used by the National Engineering Laboratory. In this respect the machine now under construction will be the only one of its kind in Great Britain.

Yours faithfully,
R. M. ROBBINS,
Chief Public Relations Officer.

London Transport Executive,
55 Broadway, London, SW1.
13 November, 1959.

COMPUTER AIDS

SIR, In the article " Research Workers' Freedom in Larger Firms," by Mr. Norman Birch, figures are given purporting to show the saving in cost which can be achieved by the use of a computer for information retrieval (ENGNG., 13 Nov. '59, p. 478). There is room for differences of opinion as to whether a computer such as the IBM 704 will ever be economical for this purpose, but the assumptions on which the graph in Fig. 2 is based are so far away from the truth as to demand a brief statement of the position.

The time taken to do an information search is made up of two factors. First, the question has to be analysed to decide the appropriate headings or codes under which required documents will be indexed. This has to be done irrespective of whether the search is to be made by computer or by normal hand searching in a conventional catalogue, and the time taken is therefore common to both methods. The second part of the operation is to carry out the search. In a card catalogue, this would not be expected to take more than five minutes at the maximum, and certainly not the two hours assumed by Mr. Birch.

Even with this greatly reduced hand search time, the computer could theoretically still show a saving by its ability to do 99 searches at once. The trouble here is that few libraries need to do so many searches in a short time. In fact, an account of the system at the organisation to which Mr. Birch refers was published recently, and it is stated that, on an average, two runs a week are made with an average of five questions per run.

There is a definite possibility that ultimately some type of machine will be able to operate economically in the field of information retrieval, but the position is not yet so clear-cut as your contributor implies.

Yours faithfully,
CYRIL W. CLEVERDON,
Librarian.

The College of Aeronautics Library,
Cranfield, Bucks.
13 November, 1959.

FUEL CONSUMPTION IN CARS

SIR, Being a car enthusiast for some 35 years and having once been an engineer, may I make some comments on your review of *The Autocar Road Tests Spring 1959* (ENGNG, 16 Oct. '59, p. 353)?

I refer to the formula for fuel consumption on page 354:—

$$\text{M.P.G.} = \frac{36}{\sqrt{\text{litres engine capacity.}}}$$

While this formula has the great merit of simplicity, and gives excellent correlation for many " ordinary " cars, I cannot see how it can but fail when applied more widely. Surely any formula should take account of other factors besides engine capacity, of which weight is probably the most important, and the degree of engine " tuning " another.

May I give two examples in support of my points? My own present car is a Jaguar XK 140, which has the standard 3·44 litre 190 b.h.p. Jaguar engine and weighs about 26 cwt. On this car I get nearly 23 m.p.g. overall average fuel consumption, including town work and touring at speeds determined by traffic but quite often up to 100 m.p.h.

The Mark VII Jaguar of the same date (1955) has the identical engine in a car weighing 35 cwt. The fuel consumption (*The Motor* test) is about 18½ m.p.g. and this is confirmed by friends of mine. Surely this difference between 18½ and 23 is due almost wholly to the difference in weight.

On my second point, a comparison can be made between the Standard Vanguard and the Triumph TR 3, where, from memory, a reduction in weight of about one-third, coupled with a tuned engine of the same capacity, gives an improvement in fuel consumption of about a quarter to a third. Some years ago I made a note of a formula worked out by a correspondent to *The Motor* (19 Jan. '55, p. 984) as follows:—

$$\text{M.P.G.} = \sqrt[3]{\frac{6{\cdot}44 \times 10^8}{\text{engine capacity in c.c.} \times \text{weight in cwt.}}}$$

This brings in my first point, but still seems to fail in special cases, of which the XK seems to be one.

Yours sincerely,
B. R. GOODFELLOW.

Imperial Chemical Industries Limited,
Millbank, London, SW1.
11 November, 1959.

COLD STORAGE BUILDINGS

SIR, We have read your article " Frost Action Below Cold Storage Buildings " (ENGNG., 11 Sept. '59, p. 159) and it may be of some interest to you to know that the phenomena described have been well understood and remedial measures taken, in this country, for many years.

The first installation to the writer's knowledge for combating " frost heave " was put in by this firm in 1947 and has been followed by many others over the years.

Your faithfully,
P. L. PULVER,
Director.

Pulver and Company Limited,
22 Fitzroy Street, London, W1.
3 November, 1959.

COMPONENT DISPENSER

38 Compartments

THE Rotasembler has been developed and constructed to supply components to the assembly line in correct sequence.

The dispensers have 19 hopper units which are vertically divided to give storage for 38 components. The whole is rotatable so that the operator only has to turn the dispenser to obtain the part required. Parts are stored in sequence so that they arrive as they are wanted to complete the assembly. Each section can hold up to 2,000 small components.

The indexing mechanism is air operated by Maxam equipment under foot control. A double-acting air cylinder works the ratchet gear through a short length of chain, turning the drive shaft and the hoppers through one position. A brake holds the hoppers still between turns.

Outside hopper dimensions are 1½ in deep by 3 in wide by 20 in high; the inside hopper is 1¼ in deep by 3 in by 24 in high. The feeding lips are located

one above the other and both have an adjustable gate to control the flow of components to the lips. The dividing plate protrudes above the tops of the hoppers to facilitate filling. The hoppers are easily removable. *Work Study Equipments, 4 Montalt Road, Woodford Green, Essex.*

STACKER

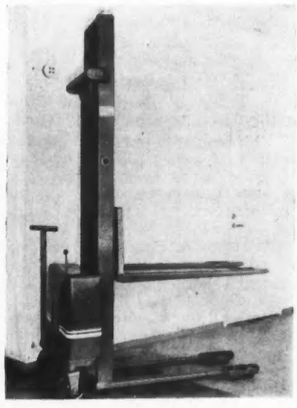
For Confined Spaces

Now available in this country are the Swedish BT SV stackers.

The range includes two weight capacities of 1,100 and 2,200 lb at 24 in centres, and four lift heights, 92, 108, 124, and 132 in. The stackers are pedestrian controlled and are driven from batteries. Mains driven models are also available. The turning radius is 69 in for an overall length of 63 in. As the unladen weight is less than 900 lb they can be used where floor loading is restricted.

All main components are one-piece pressings of high tensile steel. The hydraulic unit is said to be leak proof and has special packing material for long service. The lifting speed is 33 ft per minute for the ½ ton model and 16 ft per minute for the 1 ton machine. The lowering speed is adjustable. Single, telescopic, and free lift masts can be supplied.

It is particularly claimed that the stackers require only the minimum routine maintenance. Wear in the



lifting assembly can be taken up by simple adjustment of the carriage brackets and mast channel guides. The fitting of SKF bearings and nylon reinforced Bakelite wheels is said to give excellent manoeuvrability in confined spaces. *Rolatruc Limited, 20 Old Compton Street, London, W1.*

PANTOGRAPH ENGRAVER

Pedestal Model

MODEL D pantograph engraver is a pedestal machine with a copying range from 1 : 1 to 16 : 1.

The machine has a work area measuring 9 in by 4½ in which can be covered for full size reproductions.

A powerful motor is incorporated and eight spindle speeds are provided ranging from 2,750 r.p.m. to 18,000 r.p.m. The copyholders are interchangeable with those on other machines in the Taylor-Hobson range. A spindle for taper or parallel shank cutters can be supplied and English and Continental collets are available.

The throat is deep enough for the centre of a 33½ in disc to be engraved, and workpieces 11¼ in high can be accepted under the cutter point. The machine controls are grouped for easy operation. A cutter grinding attachment is available and other accessories include a wide range of copy sizes and styles, a forming attachment and formers, presser foot for engraving uneven surfaces, extension table, etching devices, and

dividing head. The machine will also carry out light profiling work. *Taylor, Taylor and Hobson Limited, Stoughton Street, Leicester.*

BEAM TRAMMELS

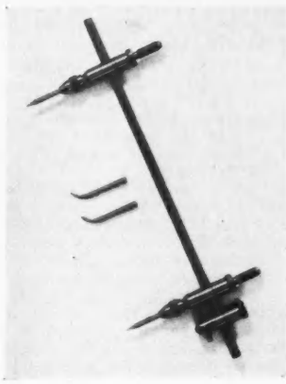
Stainless Steel

Now available are sets of beam trammels in stainless steel. Circles up to 69 in diameter can be described using extension beams.

The basic set is shown in the illustration; it consists of a fixed tram with finger grip and chuck; adjustable tram, also with finger grip and chuck; a 12 in beam; two scriber points and two caliper points. This set will describe a circle 21 in diameter.

The trams are locked on the beam by the knurled grips and final setting is obtained by the screw adjustment on one of them. It is claimed that they are suitable for both draughtsmen and tool makers.

Additional items to the basic set are extension beams; beam couplings that are fitted with gripping screws to hold both beams in the sleeve; ball point for holes up to ¼ in diameter; three sizes of ball end for holes from ¼ in to ½ in, from ½ in to 1 in, and from 1 to 1½ in diameter; pen points; pencil chuck; and adaptor points.



Two other sets as well as the basic one already mentioned are supplied: set 701/2 containing the complete range of alternative points and ends, and 701/3 which has in addition two extension beams and their couplings. All sets are supplied in cases, the first in plain wood, the second and third leather covered and velvet lined. *Moore and Wright (Sheffield) Limited, Sheffield 13.*

EXTRACTOR FAN

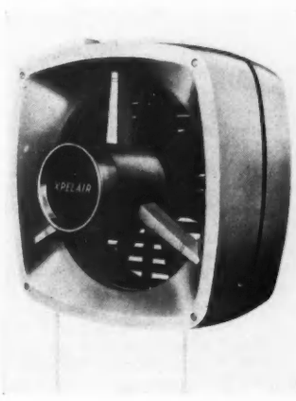
Two Speed and Reversible

AN addition to the Xpelair range of ventilation fans is a 12 in model that has two speeds and is also reversible.

Following the standard pattern, within the casing there is a built-in cord-operated iris shutter linked with an integral fan switch, the fan being switched on and off as the shutter is opened or closed.

Control of the direction can be either local or remote. For local operation, controlling is done by turning the socket connection for the mains supply through 90°. Alternatively, a remote controller can be used which gives a choice of four running speeds in either direction and an off position. Dual speed motor control also regulates the flow of air. The fan starts and runs at full speed when the right-hand cord is pulled and slows to half speed when the left-hand cord is given a short pull.

The fan unit has a compact external grille. Provision is made for mounting it either in a window or on a wall. In the case of a window, the glass should be ¼ in



thick and a 12¾ in round hole is needed. In a wall a square hole of 12¾ in is required. With shutter the unit weighs 27½ lb. The motor is of the totally-enclosed capacitor type with the capacitor in the end casing. The casing grille and impeller are plastics mouldings. *Woods of Colchester Limited, Colchester, Essex.*

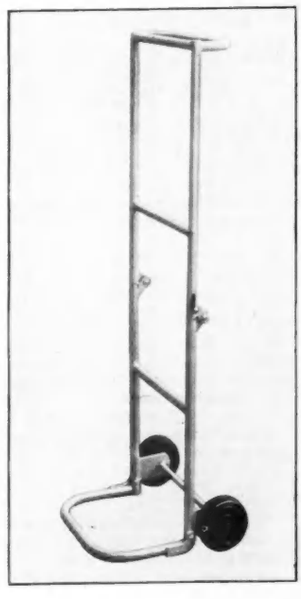
SACK TRUCK

Folds for Transport

A LIGHTWEIGHT sack truck of tubular construction has been designed to fold for stowage.

The truck weighs approximately 12 lb. When open for use it measures 3 ft 2 in high and 1 ft 3 in wide. The shoe extension gives a 6 in platform and the capacity is 1½ cwt. The construction is essentially simple. Tube of ¾ in diameter is used throughout and the truck runs on 4 in solid rubber tyred wheels which are mounted on plain bearings on a ½ in diameter solid bar axle. It is finished in a light green paint as standard.

For folding, the two bolts in the upright members are slid back and the upper portion folded backwards on to the wheels. The shoe folds forwards, making a very compact parcel. It is claimed that it will fit in the boot of a baby car; it will certainly take very little room in a lorry or delivery van. Deliveries in small quantity are its main purpose. *F. Piper and Sons Limited, 62-70 Elmington Road, London, SE5.*



MINIATURE COUNTER

Low Torque

SMALL size and low operating torque are the two chief claims for a new counter for indicating degrees.

The unit has been developed primarily for use in navigational equipment and will fit a space 1·2 in high, 1·33 in long and 0·81 in wide. It gives three-figure presentation of angular rotation or of a compass bearing.

The operating torque has been kept to a minimum so that it can be used in servo systems. At room temperature a torque of 10 gm-cm is needed to change the reading. The units drum is divided into half degrees so that it is possible to read to one-quarter of a degree. It is claimed that the problem of handling the figures above 5 on the centre drum when the number has reached 359 and must return to 000, has been overcome very simply. Only two lay shafts are used.

The instrument will operate satisfactorily over the temperature range from −40° C to +70° C. No permanent derangement is suffered at temperatures

from −60° C to +100° C. It is also stated that the counter will withstand a fore-and-aft acceleration of 25*g* without breaking loose from its mounting. Since it can be used in a servo loop it is suitable for use as a remote indicator. *Smiths Aviation Division, Kelvin House, Wembley Park Drive, Wembley, Middx.*

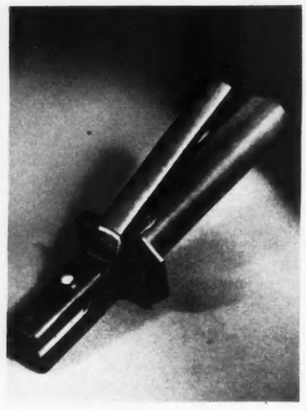
ELECTRODE HOLDERS

For Confined Spaces

TWO new electrode holders for manual arc welding are now available. A key feature is their design for work in confined spaces.

Known as the Handicool, the models differ in that one is insulated and the other is not. The levers have been angled close to the handle for working in confined quarters. Both handle and lever have D-shaped cross-sections providing a compact, well balanced grip for welding in any position. The holders are designed so that they can be held with a long grip at the end of the handle when using high currents, or with a short grip close to the jaws to give control of the electrode tip. It is stated that the holders keep cool even after long periods of welding.

On the insulated version (illustrated here) the jaws are surrounded by tough non-hygroscopic material that is resistant to heat and fracture, and which can be renewed when worn. Both holders have deep groove slots machined in the copper alloy jaws. The spring situated



behind the guard is insulated and protected from heat and splutter. The uninsulated model weighs 21 oz and the insulated one 23 oz. The maximum current is 600A and the range of electrode sizes from 10 s.w.g. to $\frac{1}{8}$ in. *Quasi-Arc Limited, 213 Oxford Street, Bilston, Staffordshire.*

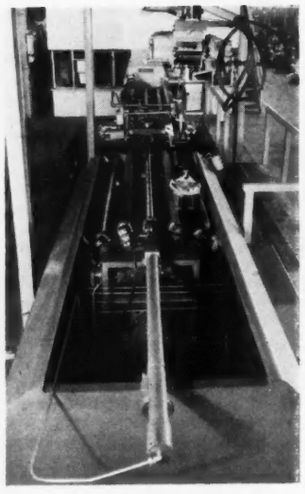
BROACHING MACHINE

19 Stations

A HORIZONTAL broaching machine with a 19 station turret will produce holes up to $2\frac{3}{8}$ in by $5\frac{1}{2}$ in by $12\frac{1}{4}$ in long is now available.

The machine has a length of 22 ft 6 in, to which must be added the turret, which is in front of the faceplate, and brings the total length up to 37 ft 6 in. The turret is 4 ft 6 in in diameter and is 21 in below floor level so that the broaches are brought in line with the machine pullhead. Normally, only 18 broaches are used to produce holes of the size given above and an open station is kept in case larger holes are required or conventional broaching performed. The broaches used are 80 in long.

Each broach is selected by the operator and each movement of the turret and the pullhead is controlled through a push-button panel. Electrical interlocks ensure the correct sequence of the 10-movement cycle. Cutting speeds are infinitely variable up to 12 ft per minute with a broach return speed of 80 ft per minute. Any broach can be replaced



in about 5 minutes and any station can be used for continuous operation. *Lapointe Machine Tool Company Limited, Otterspool, Watford By-Pass, Watford, Herts.*

FLOW METER

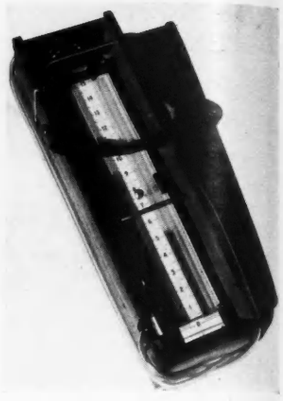
Measuring Fan Performance

THE Thorpe portable recorder has been developed primarily for checking the performance of auxiliary ventilation fans in mines.

The instrument uses the pitot-static method but has been made very compact. It consists essentially of a twin tube inclined manometer with two switch-off taps; two levelling bubbles set at right angles; a pitot-static tube and two 10 ft lengths of clear p.v.c. tubing connecting the pitot to the manometer. A 3 ft walking stick acts as an extension to the combined pitot-static tube.

The manometer has an overall length of 17 in and is covered by a Perspex scale graduated on the underside. It is set at an angle of 1 in 7·5 and levelled by wedges. A reading can be "fixed" by closing one of the shut-off taps.

The pitot-static tube is 18 in long, graduated in half inches and fitted with a movable pointer. It can only be clipped in position when both taps are off. The outfit can be used in ducting up to 30 in diameter and can record a



static pressure of 12 in w.g. and a maximum air velocity of 14,000 ft per min. The whole outfit weighs less than 10 lb. For air velocities greater than 4,200 ft per minute, the gauge must be used in the vertical position. *National Coal Board, Hobart House, Grosvenor Place, London, SW1.*

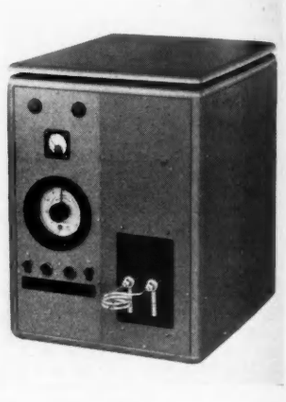
INDUCTION HEATER

Compact with Medium Impedance

THE RF2 induction heater is a compact unit with a medium impedance output rated at 1·5 kW at 2 Mc/s. It is the second in the new range.

Main features include an automatic resetting process timer, an overload relay to protect the valves, and a water pressure switch to protect the equipment. Provision is made for remote control of the unit and a pulse is available at the end of the heating cycle to initiate a quench or other subsequent operation. The safety switches are behind movable panels and a meter indicates the output power. Coloured lights show that the circuits are switched on.

The oscillator valve of the unit is radiation cooled, which removes the need for a fan or blower. The connections for the water cooled work coil are made on the front panel. The casing is aluminium and measures $24\frac{1}{8}$ in high by $17\frac{1}{2}$ in wide by $21\frac{1}{4}$ in deep. Normal operating supply is single phase from 180 to 250V, 50 cycles and the full load consumption is 3·1 kW. Only unskilled



labour is needed for the operation and all ordinary hard and soft soldering, brazing, hardening, and tempering work can be carried out. Being of medium impedance, multi-turn work coils can be used. *Pye Limited, R.F. Heating Division, 28 St. James Street, Cambridge.*

MINIATURE SWITCH

Cord Pull

FOR wall and ceiling fittings there is now being made a miniature cord pull switch.

The switch is rated for 1A at 250V for use on either direct or alternating current. An alternate quick make and break action is given. In the model illustrated, which has a long fixing ring, the terminals are screw connections; solder tag connections can also be supplied. Bottom, top and side lead entrances are available.

For the screw terminal type the switch body measures $\frac{7}{8}$ in by $\frac{1}{2}$ in by 0·35 in deep. With the long ring (which is for fixing on panels not more than $\frac{1}{16}$ in thick) the projection above the surface is $\frac{1}{2}$ in. The weight is 0·25 oz. The pull cord is white nylon, plaited, and the termination can be either a nickel plated bell or a bakelite bead in one of many colours. The fixing ring itself is available in nine colours to suit the surroundings. *Castelco (Great Britain) Limited, Castle Works, High Street, Old Woking, Surrey.*

MACHINE TOOL PROSPECTS

Pressure was put upon the Minister of Education by a number of Members of the House of Commons at the end of last week, for a statement about conditions in the British machine tool industry. It was affirmed by Mr. Maurice Edelman (Labour) that a report by the Department of Scientific and Industrial Research had dealt with the size, efficiency, capacity for research and future prospects of the industry, and both he and Mr. Austen Albu (Labour) were anxious that this report should be published in its entirety.

Speaking on behalf of Viscount Hailsham, the Minister for Science, whose representative he is in the Commons, Mr. Kenneth Thompson, the Parliamentary Secretary to the Ministry of Education, said that the report of the Department's investigations had been circulated in full, and in confidence, to the leaders of the machine tool industry. These machine tool representatives were now discussing the conclusions and recommendations of the report with the Department. The DSIR had received considerable help from the industry in making the investigations and was given information by the cooperating firms on the understanding that no publication was intended. In these circumstances, Lord Hailsham did not feel that he could agree to publish the report.

Referring to comments by Mr. Albu, that the industry undertook far too little research and development, particularly in the use of electronic controls, that there was increasing competition from other countries, and that the industry employed too few graduates, Mr. Thompson said that, whatever the truth in the detail of these remarks, they all fitted into the view that, when Lord Hailsham had had discussions with the industry, he would be in a better position to decide whether to make a statement.

POSITION IN THE MOTOR INDUSTRY

Urging that the situation in the machine tool industry was urgent as well as serious, Mr. Edelman said that if the minister were to walk through a major Coventry motor works he would find that the most advanced machines were German, Swiss or French. The decline in the industry, represented by the drop in the order book from nearly £90 million in 1957 to about £60 million at the present time, was directly due to inadequate investment in research and development. It also derived from an undue, though profitable, concentration on traditional lines. He asked what the Government intended to do to bring the industry into line with foreign competition.

Mr. Frederick Lee (Labour) said that Members were asking why the nation could not be told the nature of the report. The machine tool industry was the genesis of most of the manufacturing industries in Great Britain. It was, therefore, not a question of whether the people running the machine tool industry were satisfied: it was a question of the economic health of the country and the levels of employment. Would the Minister again look into the request for a public report of the findings of the DSIR? Mr. Thompson answered that the Government now had the benefit of the report and they should have a chance to consider it.

TEXTILE MACHINERY PRODUCTION

Later, Mr. Thompson informed Mr. Albu, who wanted a similar inquiry to be undertaken by the DSIR into the situation in connection with Britain's production of textile machines, that the Department proposed to investigate, in turn, the research and development needs of other industries. Those to be studied in this way would be the industries which, on the available evidence, appeared not to be attracting a sufficient share of the nation's resources for technological development. Lord Hailsham would bring to the attention of the Research Council the suggestion that the industry making textile machinery might be included at an early stage in their plans.

It was pointed out by Mr. Sydney Silverman (Labour) that one of the two main purposes of the Cotton Industry Act passed last July was to enable the mills that remained in the industry to re-equip themselves with modernised machinery. It therefore became increasingly necessary that the British textile machinery industry should be ready to deal with what might be a very large demand. Mr. Cyril Osborne (Conservative) stressed another view. He said that certain sections of the textile machinery building industry were at present selling large quantities of their products to Russia and that the Russians bought only the finest machines in the world.

WHO GO TO UNIVERSITIES?

Dr. Horace King (Labour) wanted the Government to invite the National Foundation for Educational Research to investigate further the disparity between the numbers of public school and State entrants to the older universities and the respective performances of both groups. He pointed out that a report seemed to show that twice as many public school boys as State grammar school boys went to Cambridge and that, when there, they did only half as well. Mr. Kenneth Thompson, in reply, said that the study recently conducted by the Cambridge University Sociological Society was being examined, although, of course, the selection of students was primarily a matter for the universities themselves. Mr. Thompson felt that that was as far as he ought to go at that stage.

AIRCRAFT INDUSTRY'S FUTURE

Consideration was being given, said Mr. Duncan Sandys, the Minister of Aviation, to finding out how the Government could help aircraft manufacturers to increase their civil business. Although there was a rising demand for civil aircraft, however, it would be some time before civilian orders would be sufficient to make good the decline in military requirements. He had no plans for expanding the total production of aircraft.

When Mr. John Rankin (Labour-Cooperative) described the Minister's remarks as sounding "very disappointing," Mr. Sandys replied that he was looking at the whole question of research and development in the industry, but that was a different matter from the expansion of aircraft production. The fact was that at the moment there were too many firms chasing too few orders. There was no doubt that the majority of the manufacturers recognised that some extensive reorganisation of the industry was essential and urgent. He would do everything he could to help them and to encourage them to carry out that reorganisation.

USA DEVELOPING THE HOVERCRAFT

Concern about the steps being taken in the United States to develop the Hovercraft was expressed by Mr. Barnett Janner (Labour). He said that work was now being carried out in America by the Curtiss Wright Corporation, the Ford Company, the General Dynamics Corporation, the Gyrodyne Corporation of America, Spectronics Incorporated, the Doak Aircraft Company, Piasecki Aircraft, and others. Were adequate steps being taken, he inquired, to maintain full development progress in this field of transport in the United Kingdom? He urged that proper support should be given to research work in this connection, particularly in view of the large measure of success which was being achieved by the firms he had mentioned. It was an urgent matter that Britain should maintain her lead in this very important industry which she had initiated.

Mr. John Rodgers, the Parliamentary Secretary to the Board of Trade, said he was aware that work was proceeding in the United States on various forms of vertical take-off and ground-effect vehicles, but much of this work was apparently at the research stage. Among the ground-effect machines, those using annular jets might well prove to be the most versatile in their possible uses. In this class, the British Hovercraft, sponsored by the National Research Development Corporation, was, the Government considered, the most advanced. The Corporation's subsidiary, Hovercrafts Development Limited, was in touch with a number of firms regarding possible manufacture.

The position was being carefully watched. The Government considered that they were in the lead and they intended to keep it. Three directors of Hovercrafts Development had already visited the United States to investigate what was being achieved there.

Dissolution of the Ministry of Supply

Functions previously carried out by the former Ministry of Supply, Sir Edward Boyle, Bt., Financial Secretary to the Treasury, told Mr. Osborne, would in future be discharged by other departments, mainly the War Office and the Ministry of Aviation. The staff would go, with the functions, to the new departments. He had no reason to suppose that these changes, in themselves, would lead to redundancy, but it was too early to say what the effect would be on total staff numbers or on costs.

Great Ouse Flood Protection Scheme

Flood protection work sponsored by the Great Ouse River Board is being undertaken in three parts, according to information given by Mr. J. B. Godber, Joint Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food. He told Mr. John Parker (Labour) that the first part had already been completed. The second part should be finished by the end of 1961 and it was hoped that the third part, the construction of the cut-off channel, would be started early in 1960. Technical discussions between the engineers were now almost completed and the Minister of Agriculture hoped that the river board could shortly be authorised to invite tenders.

Private Enterprise Coalmining

No fewer than 196 licensed mines are in production in South Wales and Monmouthshire, according to an answer by Mr. J. C. George, the Parliamentary Secretary to the Ministry of Power. The mines employ 2,100 men and have an average weekly output of 14,000 tons of coal. In the same area, the National Coal Board was operating 13 opencast sites employing 1,600 men. Production during the first 42 weeks of 1959 was 1,250,000 tons. During that period, 7 licensed opencast sites produced 29,000 tons, but the level of employment at these sites, he told Mr. D. J. Williams (Labour), was not known.

Dounreay Power Station

The nuclear power station at Dounreay is primarily a research and development establishment. In this connection, Mr. John Maclay, the Secretary of State for Scotland, told Mr. Hector Hughes (Labour) that the amount of electricity produced was likely to be small. Any surplus would be made available to the North of Scotland Hydro-Electric Board.

Continuing Negotiations on Indus Waters

Since mid-June last representatives of the International Bank and of the Governments of India and Pakistan have held discussions on the disposal of the Indus Valley waters. Mr. C. J. M. Alport, Minister of State for Commonwealth Relations, informed Mr. G. M. Thomson (Labour) that these discussions, directed to the negotiation of a water treaty still continued. The International Bank had made proposals to the British Government as well as to other friendly governments for a scheme for the financing of the settlement which it was hoped would be reached. These proposals were under consideration by the British authorities. As friends of both countries, Britain would certainly help in any way she could.

MEETINGS AND PAPERS

British Institution of Radio Engineers

CHELTENHAM
"A Vidicon Television Camera Channel," by B. J. Pover. South Midlands Section. North Gloucestershire Technical College, Cheltenham. Fri., 27 Nov., 7 p.m.

British Nuclear Energy Conference and Institution of Chemical Engineers

LONDON
Nuclear Energy Symposium: "Second Uranium Production Plant at Springfields," by R. C. Alexander, L. P. Shortis and C. J. Turner; "Processing of Uranium Concentrates and Recycle Residues to Purified Uranyl Nitrate at Springfields," by H. Page, L. P. Shortis and J. A. Dukes; "Fluidised Solids Dryway Process for the Production of Uranium Tetrafluoride at Springfields," by E. Hawthorn, L. P. Shortis and J. E. Lloyd; "Pumping Studies on Aqueous Thoria Slurries," by R. Murdoch and H. A. Kearsey; and "Use of Hydrogen as a Reactor Coolant," by D. Bradley. Royal Institution, Albemarle Street, W1. Tues., 24 Nov., 2.30 p.m.

Combustion Engineering Association

DUNDEE
"Utilisation of Small Coals." Discussion opened by R. Cleland, at 10.30 a.m.* Discussion on "Coal to Oil Conversion," opened by L. H. W. Savage, at 2 p.m. Royal Hotel, Union Street, Dundee. Wed., 25 Nov.
MANCHESTER
"Incentive Schemes for Boiler Operators." Brains Trust Meeting. North Western Region. Engineers' Club, Manchester. Tues., 24 Nov., 2.30 p.m.
PORTHCAWL
"Development of Coal Production and Preparation," by A. W. Davis; and Film Display, at 11 a.m.* Another Film Display at 2.15 p.m. Western Region. Seabank Hotel, Porthcawl, Glam. Thurs., 26 Nov.

Illuminating Engineering Society

LEEDS
"Polarised Light and Its Applications," by D. L. Smare. Leeds Centre. British Lighting Council, 24 Aire Street, Leeds 1. Mon., 23 Nov., 6.15 p.m.
LEICESTER
"Modern Lighting in Production," by L. E. Gibbs. Leicester Centre. Offices of the East Midlands Electricity Board, Charles Street, Leicester. Mon., 23 Nov., 7 p.m.

Institute of Fuel

LONDON
"Surface: A Common Problem for Research and Engineering in Fuel Technology," by Dr. P. O. Rosin. Institution of Civil Engineers, Great George Street, SW1. Wed., 25 Nov., 5.30 p.m.*
GLASGOW
"The Turbo Furnace," by G. Williams. Scottish Section. Royal College of Science and Technology, Glasgow. Tues., 24 Nov., 7 p.m.

Institute of Marine Engineers and Institution of Naval Architects

PORTSMOUTH
"Marine Lubricants and the Use of Additives," by R. W. Bale. Southern Joint Branch. College of Technology, Portsmouth. Thurs., 26 Nov., 7.30 p.m.

Institute of Marine Engineers

LONDON
"Human Problems in Marine Engineering," by C. C. Pounder, at 3 p.m. "Coordinated Alignment of Line Shaft, Propulsion Gear and Turbines," by J. J. Zrodowski and H. C. Andersen, at 5.30 p.m.* Thurs., 26 Nov.
BELFAST
"Reactor Design, Particularly of Types Suitable for Marine Propulsion," by E. Long. College of Technology, Belfast. Fri., 27 Nov., 7.30 p.m.
BIRMINGHAM
"Manufacture of Thick Walled Seamless Pressure Tubes," by R. R. Gilchrist. West Midlands Section. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham. Thurs., 26 Nov., 7 p.m.

Institute of Sheet Metal Engineering

MANCHESTER
"Application of Cold Rolled Sections," by E. Griffin. North West Branch. Engineers' Club, Manchester. Wed., 25 Nov., 7 p.m.

Institute of Welding

WEYBRIDGE
"Welding and the Draughtsman," by H. B. Merriman. South London Branch. Joint Meeting with the Royal Aeronautical Society. At works of Vickers-Armstrongs (Aircraft) Ltd., Weybridge. Thurs., 26 Nov., 6.10 p.m.

Institution of British Agricultural Engineers

BIRMINGHAM
"Latest Developments in Metallurgy with Possible Agricultural Engineering Uses," by J. Williams. West Midlands Centre. Gosta Green Technical College, Birmingham. Mon., 30 Nov., 7.30 p.m.

Institution of Civil Engineers

LONDON
"Mechanisation of Railway Civil Engineering Maintenance Works," by Arthur Dean, Peter Chalmers and A. C. Layhe. Tues., 24 Nov., 5.30 p.m.*
"Is the Practical Training of Civil Engineers Adequate?" Debate opened by G. A. Wilson, Arthur Dean and Charles Brand. Thurs., 26 Nov., 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Radio Aspects of the International Geophysical Year," by Dr. R. L. Smith-Rose. Electronics and Communications Section. Wed., 25 Nov., 5.30 p.m.*
"Application of Low-Pressure Resins to Some High-Voltage Switchgear Designs," by T. R. Manley, K. Rothwell and W. Gray. Thurs., 26 Nov., 5.30 p.m.*
BIRMINGHAM
"Organisation of Courses for Electrical Technicians." Discussion opened by Professor M. W. Humphrey Davies. South Midland Centre. College of Technology, Gosta Green, Birmingham. Thurs., 26 Nov., 6.15 p.m.
BRADFORD
"A System for the Automatic Recognition of Patterns," by Dr. R. L. Grimsdale, Dr. F. W. Sumner, Dr. C. J. Tunis and Dr. T. Kilburn. North Midland Centre. Institute of Technology, Bradford. Tues., 24 Nov., 6.30 p.m.*
GLASGOW
"Electrical Machines," by Professor M. G. Say. Faraday Lecture. Scottish Centre. St. Andrew's Hall, Glasgow. Wed., 25 Nov., 7.30 p.m. (Tickets, obtainable free, are required.)
LOUGHBOROUGH
"Development of High-Voltage Air-Break Circuit Breakers, with Insulated-Steel-Plate Arc Chutes," by F. S. Fay, J. A. Thomas, D. Legg and J. E. Morton. East Midland Centre. College of Further Education, Loughborough. Tues., 24 Nov., 6.30 p.m.*
MANCHESTER
"Modern Applications of Field Plotting." Discussion opened by E. R. Hartill. North Western Centre. Engineers' Club, Manchester. Mon., 23 Nov., 6.15 p.m.
NEWCASTLE UPON TYNE
"Application of Low-Pressure Resins to Some High-Voltage Switchgear Designs," by T. R. Manley, K. Rothwell and W. Gray. North Eastern Centre. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 23 Nov., 6.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
Informal Discussion Meeting. Tues., 24 Nov., 6.30 p.m.*

Institution of Heating and Ventilating Engineers

EDINBURGH
"Air Treatment in Hospitals," by W. Russell. Scottish Branch. 25 Charlotte Square, Edinburgh. Tues., 24 Nov., 7 p.m.

Institution of Mechanical Engineers

LONDON
"Vibration Theory, Linear Systems and the Subject 'Theory of Machines'." Education Group Discussion. Mon., 23 Nov., 6 p.m.*
"Effect of Nuclear Radiation on Engineering Materials," by Professor A. H. Cottrell. Thomas Hawksley Lecture. Wed., 25 Nov., 6 p.m.* (Tickets required.)
"Application of Creep Results to Engineering Design." Applied Mechanics Group Discussion. Thurs., 26 Nov., 6 p.m.*
BRIGHTON
"Work of Research Engineers." Discussion opened by E. N. Soar; and a Discussion on "The Sales Organisation of CVA Jigs, Moulds and Tools Ltd.," opened by H. M. Lebrecht. Southern Branch. Royal Pavilion Hotel, Castle Square, Brighton. Thurs., 26 Nov., 7.15 p.m.
BRISTOL
"Modern Aids in the Design of Railway Bogies," by A. W. Manser. Western Branch. Engineering Laboratories, The University, Bristol. Tues., 24 Nov., 7 p.m.*
CARDIFF
"Refrigeration for Marine Cargo Purposes," by H. R. Howells. Thomas Lowe Gray Lecture. South Wales Branch. South Wales Institute of Engineers, Park Place, Cardiff. Tues., 24 Nov., 6 p.m.
MANCHESTER
"Management Accounting for the Small and Medium Size Company," by A. J. Platt. North Western Branch. Engineers' Club, Albert Square, Manchester. Thurs., 26 Nov., 6.45 p.m.

Institution of Plant Engineers

BIRMINGHAM
"Instrumentation in Industry, with Particular Reference to the Control of Temperature, Pressure Flow, Weight, etc.," by L. F. Cohen. Birmingham Branch. Imperial Hotel, Temple Street, Birmingham. Fri., 27 Nov., 7.30 p.m.
CARDIFF
"Engineering Applications of Electro-Deposited Metals," by J. W. Oswald. South Wales Branch. South Wales Institute of Engineers, Park Place, Cardiff. Tues., 24 Nov., 7.30 p.m.
SHEFFIELD
"Some Modern Steel for the Engineer," by E. Johnson. Sheffield Branch. Grand Hotel, Sheffield. Thurs., 26 Nov., 7.30 p.m.

Institution of Production Engineers

CARDIFF
"Photography in Engineering," by P. H. Herbert. Cardiff Section. South Wales Institute of Engineers, Park Place, Cardiff. Fri., 27 Nov., 7 p.m.
LINCOLN
"Modern Techniques in Presswork," by J. A. Grainger. Lincoln Section. Ruston Club, Lincoln. Thurs., 26 Nov., 7.30 p.m.
MANCHESTER
"Diploma in Technology," by Dr. C. W. Whitworth. Manchester Section. Manchester College of Science and Technology, Sackville Street, Manchester. Mon., 23 Nov., 7.15 p.m.
SHREWSBURY
"Fabrication of Nuclear Power Plants," by S. H. Griffiths. Shrewsbury Section. Walker Technical College, Oakengates, Shrewsbury. Wed., 25 Nov., 7.30 p.m.
WORCESTER
"High Cost of Low Overheads," by C. H. Starr. Worcester Section. Star Hotel, Worcester. Wed., 25 Nov., 7.30 p.m.

Institution of the Rubber Industry

MANCHESTER
"Developments in Flame and Ozone Resistant Compounds," by L. Bustos, G. Cornil, W. A. Tandy and J. Walker. Manchester Section. Engineers' Club, Albert Square, Manchester. Tues., 23 Nov., 6.45 p.m.

Institution of Structural Engineers

LONDON
"A Commentary on the New British Standard 449 (1959): The Use of Structural Steel in Building," by John Mason. Thurs., 26 Nov., 6 p.m.*
BIRMINGHAM
"A Commentary on the New British Standard 449 (1959): The Use of Structural Steel in Building," by John Mason. Fri., 27 Nov., 6.30 p.m.

Iron and Steel Institute

SHEFFIELD
"Phenomena Occurring in Steels During Quenching and Tempering," by Academician G. V. Kurdjumov (Moscow). Hatfield Memorial Lecture. Firth Hall, The University, Sheffield. Wed., 25 Nov., 6.30 p.m.

Junior Institution of Engineers

LONDON
Annual General Meeting. Fri., 27 Nov., 7 p.m.*

Manchester Association of Engineers

MANCHESTER
"The Craft of Needle Making," by H. J. Paramore. Engineers' Club, Albert Square, Manchester. Fri., 27 Nov., 6.45 p.m.

Operational Research Society

LONDON
"The Art of Exposition." Presidential Address by the Earl of Halsbury. Royal Society of Arts, John Adam Street, Adelphi, WC2. Fri., 27 Nov., 6 p.m.*

Reinforced Concrete Association

BRISTOL
"Factory Production of Precast Concrete," by F. W. Gifford. West of England Branch. New School of Engineering, The University, Bristol. Thurs., 26 Nov., 6 p.m.*

Royal Aeronautical Society

LONDON
"Heat and Mass Transfer in Aeronautical Engineering," by Professor D. B. Spalding. Tues., 24 Nov., 7 p.m.
"Some Developments in Boundary Layer Research in the Last Thirty Years," by Professor Dr. H. Schlichting. Lanchester Memorial Lecture. Church House, Great Smith Street, London, SW1. Thurs., 26 Nov., 6 p.m.*
"Man as an Aero Engine," by Dr. D. R. Wilkie. Man Powered Aircraft Group. Fri., 27 Nov., 7 p.m.

Royal Society of Arts

LONDON
"Commercial and Higher Professional Education," by Dr. A. J. McIntosh. Mon., 23 Nov., 6 p.m.*

Royal Statistical Society

SHEFFIELD
"Rehearsal for Business," by Dr. J. Laski. Sheffield Group. Grand Hotel, Sheffield. Thurs., 26 Nov., 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Determination of Carbon in Steel." Symposium arranged by the Methods of Analysis Group. "Gravimetric Methods," by E. A. Dickinson; "Low Pressure Method," by R. Statham; and "Conductimetric Method," by W. R. Nall. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 24 Nov., 7 p.m.

Society of Instrument Technology

LONDON
"Application of Instrumentation to Glass Melting Furnaces," by N. I. Walker. Manson House, 26 Portland Place, W1. Tues., 24 Nov., 7 p.m.*
GLASGOW
"Magnetic Flow Meter," by B. W. Balls. Scottish Section. Building Centre, Sauchiehall Street, Glasgow. Fri., 27 Nov., 7.15 p.m.
GRANGEMOUTH
"Magnetic Flow Meter," by B. W. Balls. Grangemouth Section. Ellwyn Restaurant, Newlands Road, Grangemouth. Thurs., 26 Nov., 7 p.m.
NEWPORT
"Transistors," by S. S. Goldberg. South Wales Section. Newport and Monmouthshire College of Technology, Newport. Wed., 25 Nov., 6.45 p.m.

The address and telephone number of the headquarters of each Institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this feature should reach the Editor at least three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Institution of Radio Engineers, 9 Bedford Square, London, WC1. (MUSeum 1901)
British Nuclear Energy Conference, Great George Street, London, SW1. (WHItehall 4577)
Combustion Engineering Association, 70 Jermyn Street, St. James's, London, SW1. (WHItehall 5536)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215)
Institute of Fuel, 18 Devonshire Street, Portland Place, London, W1. (LANgham 7124)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, EC3. (ROYal 8493)
Institute of Sheet Metal Engineering, John Adam House, Adelphi, London, WC2. (TRAfalgar 6171)
Institute of Welding, 54 Princes Gate, Exhibition Road, London, SW7. (KNIghtsbridge 8556)
Institution of British Agricultural Engineers, 6 Buckingham Gate, London, SW1. (TATe Gallery 8589)
Institution of Chemical Engineers, 16 Belgrave Square, London, SW1. (BELgravia 3647).
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (COVent Garden 1871)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C2. (Central 5181)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, SW1. (SLOane 3158)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. (WHItehall 7476)
Institution of Naval Architects, 10 Upper Belgrave Street, London, SW1. (SLOane 4622)
Institution of Plant Engineers, 2 Grosvenor Gardens, London, SW1. (SLOane 0469)
Institution of Production Engineers, 10 Chesterfield Street, London, W1. (GROsvenor 5254)
Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W8. (BAYswater 9101)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, SW1. (SLOane 7128)
Iron and Steel Institute, 4 Grosvenor Gardens, London, SW1. (SLOane 0061)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, SW1. (VICtoria 0786)
Manchester Association of Engineers, 18 Booth Street, Manchester 2. (Central 1717)
Operational Research Society, 64 Cannon Street, London, EC4. (CITy 1800)
Reinforced Concrete Association, 94-98 Petty France, London, SW1. (ABBey 4504)
Royal Aeronautical Society, 4 Hamilton Place, London, W1. (GROsvenor 3515)
Royal Society of Arts, John Adam Street, Adelphi, London, WC2. (TRAfalgar 2366)
Royal Statistical Society, 21 Bentinck Street, London, W1. (WELbeck 7638)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251)

Sir David Rushes In

Sir David Eccles, the well-known optimist and Minister of Education, has wasted no time on returning to that ministry after his tour of duty at the Board of Trade.

In a message sent to mark the start of the £2 million extension to Loughborough College of Technology, he paid tribute to the already famous name of Loughborough in technical education and was sure that the scheme would make a big contribution to "the national aim of doubling within a decade the output of scientists and technologists."

Travelling in person to Newcastle, Sir David boldly stated that if you went to Moscow you could not help being impressed by the technological institutions, but ours were not going to be in any way behind. Disregarding the double rate of output of scientists and technologists in the Soviet Union compared with our own, the Minister warned his audience: "Don't let us get into our heads that we are falling a long way behind—don't believe that for a moment." The Russians were "miles behind" in production methods of certain consumer goods—synthetic fibres, tyres and plastics. Perhaps Sir David was on surer ground when he hoped that we might do a great deal better than the Russians in achieving a more balanced education with liberal studies in addition to science.

Loughborough, to which Sir David sent his message, is to become the largest residential technical college in Britain. One of the eight Colleges of Advanced Technology, it will have accommodation for 1,500 students on full-time and sandwich courses, 1,100 students will live on the campus, a 44 acre site of teaching buildings, students' "village" with its own shops and 150 acres of open space.

It is hard to imagine how the benefits of university residence could be more fully brought to technical education.

A dominating architectural feature of the village will be a nine-storey block for post-graduates. Six storeys high will be the science block. This is to have aeronautical and automobile engineering laboratories with sound-insulated test houses and nuclear energy laboratories. There will also be a workshop engineering block designed as a miniature factory for instruction in production techniques.

New RAF Supply Chief

Air Marshal Sir Walter Hugh Merton has been appointed Air Member for Supply and Organisation with effect from April, 1960. He will succeed Air Marshal Sir Walter L. Dawson. Air Marshal Merton will be succeeded as Chief of Staff, Allied Forces Central Europe, by Air Vice-Marshal D. G. Morris.

Air Marshal Merton entered the RAF in 1924 and was serving in Bomber Command at the outbreak of the Second World War. In due course he became Assistant Commandant of the RAF Staff College and then spent 18 months as Director of Organisation at the Air Ministry. Since the war he has served as Air Attaché in Prague, has served as AOC and head of the RAF delegation in Greece and has commanded Groups in Technical Training and Home Commands.

Some New Headmen

Dr. Robert Hunter, who is deputy managing director of the Clyde Alloy Steel company, has been elected chairman of the British Steel Castings Research Association. Mr. W. S. Scott, a director of Darlington Forge Limited, succeeds Dr. Hunter as vice-chairman of the association.

Dr. Maurice Cook, retiring chairman of the British Non-Ferrous Metals Research Association, is to be followed in office by a past-president of the Engineering and Allied Employers National Federation, Mr. F. C. Braby. Mr. Braby, who is chairman and managing director of Fredk. Braby, graduated at Manchester. In his former capacity as a leader for the employers he has taken part in some very tough bargaining with the unions.

Fourteen Days in This Week

Development projects, the working of the Colombo plan, and graphic illustrations of the interdependence of the countries of the Commonwealth, will be among the special features of the series of Commonwealth Weeks to be held in a number of major centres from this month until next spring.

There is so much to be told, that each of the weeks will last a fortnight. Princess Margaret will open the first at Liverpool on 19 November and the order will be—Liverpool (19 November-5 December), Leeds (7-23 January), Birmingham (4-20 February), and followed by Norwich (3-17 March).

Sponsored by the Commonwealth Relations Office and the Colonial Office, and produced by the Central Office of Information, the touring Commonwealth exhibition covers 4,000 sq. ft. It is a good deal easier for those Londoners who want to find out about the Commonwealth and what are called the dependent territories than for people living in the provinces. This exhibition, the first of so comprehensive a nature, will be doing a valuable public relations job in a double direction; in showing what is being undertaken and in demonstrating a little of what waits to be done.

A large number of organisations will be hearing lectures on activities in the Commonwealth while the weeks are running, art exhibitions and film shows will be used, and, as ever, there will be traditional dancing and music.

In addition to the four centres that have already been listed, the touring exhibition will be seen in ten other cities.

Bidding for the Lot

An oration under the intriguing title "Bidding for the Lot" is to be given by Professor R. Y. Goodden, Master of the Faculty of Royal Designers for Industry, at the Royal Society of Arts, on Monday, 30 November. Professor Goodden will be speaking after the presentation of diplomas of the distinction of the Royal Designer for Industry.

Tickets for the occasion can be obtained from the secretary of the RSA, John Adam Street, London, WC2.

Away with August Bank Holiday

If the August bank holiday is famous for anything at all it is for mighty traffic jams, although this year the jammers transferred themselves to the week-ends immediately before and after the holiday, and to furious airline movements by those who are able to turn the bank holiday into a four day week-end.

With a fortnight's holiday usual and three weeks not uncommon the value of bank holidays in general, and the August one in particular, has become less and less obvious. Time losing and production reducing for industry, the gain to the employee has become highly problematical.

Shifting the date to a time of the year when it might do us all some good concerns more than the transport systems—employers, trade unions, hoteliers and cafe keepers, these and others would all be affected.

Always well to the front in current issues, the Industrial Welfare Society is holding a conference at its London headquarters (48 Bryanston House, London, W1) on 8 December when executives from industry and commerce will talk the thing over. They will hear a spokesman from the British Travel and Holidays Association and another from the National Union of Teachers. Non-members of the Society are welcome, says IWS.

Living on Wheels

Some 60,000 caravans in England and Wales are the homes of about 150,000 people, according to a survey undertaken by Sir Arton Wilson, former permanent secretary to the Ministry of Pensions.

The social phenomenon of a part of the working population living under such conditions is a bi-product of the age we live in. It is the result of a housing shortage, high employment, high cost of living and the growth of new industrial areas. The typical caravan dweller, according to the survey, is not shiftless but probably above average in initiative. Vagrants and gypsies are not included in the investigation. A significant portion of caravan dwellers are older people looking for cheap accommodation for retirement. Caravan sites for permanent dwellings are rising quickest at the edge of new urban areas where there are no incipient slums to hide the problem of housing for families moving in to new jobs. Hire purchase is making it possible for today's workers (caravan dwellers are predominantly from the more enterprising sections of the wage earners) to acquire a caravan. These people are property owners if only in a humble way.

The survey does little more than state the problem and show up the opposing pressures of local authorities who want to control the sites and site owners who want development restrictions eased. In between is the bone of contention—the caravan owner who badly needs better accommodation and seems likely to go on wanting it for quite a long time.

Our Man at the ILO

Sir Guildhaume Myrddin-Evans first represented this country at the International Labour Organisation at its last conference before the Second World War began. Apart from the 1941 conference at New York in 1941, he has gone on representing the government at the ILO ever since.

Now, as the ILO prepares to celebrate its 40th anniversay, Sir Guildhaume, chief international labour adviser to the government and a deputy secretary at the Ministry of Labour, retires from the public service.

He began his experience of administration in the cabinet secretariat after being invalided from the South Wales Borderers in 1917. The year after the war ended he became assistant secretary to the War Cabinet, serving in the Treasury for ten years and then moving to the Ministry of Labour.

Ten years ago Sir Guildhaume had the distinction of being the first civil servant to be appointed president of the ILO conference. Before retiring he is attending this month's meeting of the ILO governing body in Geneva, when he will be accompanied by Mr. H. F. Rossetti, a deputy secretary at the Ministry, who is to succeed him.

Illuminating Engineering Gold Medal

Dr. John W. T. Walsh is the first recipient of the gold medal of the Illuminating Engineering Society. This award has been instituted to mark the golden jubilee of the Society. Dr. Walsh was connected with the National Physics Laboratory, notably with the photometry department, for 38 years, retiring in 1951. His outstanding publications on light have been his treatise on photometry and his *Textbook on Illuminating Engineering*.

Materials Matter

IN the infancy of nuclear power it was thought that fuel would not make an important addition to the cost of power generation. In fact, a typical cost distribution for stations in the 20 MW(e) range using enriched fuel is the following: fuel 39 per cent; fixed charges 46 per cent; operation and maintenance 15 per cent. Even in a 200 MW(e) natural-uranium heavy-water moderated station, which promises the lowest fuel cost, it will amount to 27 per cent. The relationship of conventional and nuclear fuel costs determines which method of power generation will prove to be more economical. At present conventional fuels have the advantage, but it is encouraging that fuel fabrication is a very new craft and much is being done to reduce costs.

Argonne Fuel Fabrication

A good example of modern fuel fabrication is the new Argonne National Laboratory plant shown in Fig. 1. It was built for use as a development laboratory, a pilot plant, and a facility for the limited production of plutonium fuel elements. A building 245 ft by 72 ft wide has been constructed for the purpose. Parts of the building where radioactivity may be present are sealed. Main exterior walls are of monolithic reinforced concrete, sealed on the outside with polyester and on the inside with vinyl paint. Floors in radioactive areas are built up of glass fibre and polyester coating. Three working zones in the building—administration, technical, and fabrication—are sealed from each other by airlocks. The technical area contains storage vaults for radioactive materials, a machine shop, and dark rooms. Three airlocks with electrically operated doors isolate the active area from other parts of the building.

Helium Atmosphere

Fuel fabrication is carried out in a single room 165 ft long by 72 ft wide, unobstructed by columns. Equipment weighing from a few pounds to nearly 50 tons is housed there in a system of gas tight interconnected enclosures (glove boxes) provided with a helium atmosphere. Besides inertness, helium has other useful properties in this application: it has high heat capacity and good heat transfer characteristics; it can be purified by regenerative physical means, and highly sensitive leak detectors are available. About 10,000 cu. ft of helium is kept in motion through the process enclosures. Loss is estimated at 200-400 cu. ft per week, depending on the number of times objects are put in or taken out of the system.

There are 106 hoods or gloveboxes in the integrated system. Four main types of work are carried out: fabrication and development of reactor fuels containing plutonium alloys; assembly, welding, and loading of previously fabricated plutonium cores into non-radioactive cans; machining, cutting, or heat treatment of canned fuels; and inspection and similar operations on fabricated fuel elements for which no protection is required.

Material Transfer

A specialised hood line (2) is used to put in or take out materials, contaminated materials being handled by plastic pouch transfer techniques. Operating hood lines are interconnected by means of a 102 ft long hooded conveyor (1). It consists of two rails on which a dolly is drawn by a continuous roller chain. Transfer from the conveyor line to the operation hood lines (3 to 12), is made on a two-way ball-bearing slide platform. The transition and operating hood lines are laid out with their longitudinal axes at 135° to the conveyor line, allowing the transfer of pieces 6 to 8 ft long into a conveyor enclosure 30 in wide. Each operating hood line is separated from the conveyor by means of a gas tight, pneumatically operated door. The machine shop line (3) contains a 50 ton hydraulic press, a 10 in toolmaker's lathe, a vertical milling and boring machine, sheet metal shear, universal milling tool grinder, and a milling machine. The centrifugal casting line contains two vertical spindle, rotating table, vacuum centrifugal casting machines capable of melting 10 kg of plutonium alloy at 0·0001 mm mercury and casting the alloy under centrifugal forces of up to 80 *g* in multiple permanent moulds.

BR-2 Fuel

BR-2, the Belgian test reactor, has a rigorous specification for its fuel elements. Requirements are a round configuration, ability to admit experimental equipment to the centre, and ability to dissipate a surface heat flux of $1{\cdot}25 \times 10^6$ Btu per hour per sq. ft. The element chosen consists of 6 concentric tubes of aluminium-uranium alloy, clad with aluminium. A summary of the fabrication techniques is given in "Fabrication of BR-2 Fuel Elements," by A. Strasser (Nuclear Engineering and Science Conference, paper V-85). Attempts at co-extrusion and co-drawing of fuel and can were unsuccessful. Later efforts were directed to assembling tubes from plates. A tube made of one or more plates has to have a seam. To avoid the bowing that would be caused by a seam—which contains no fuel—three seams spaced at 120° are used. Fabrication methods tested included welding or brazing three curved plates into a tube; assembling three plates into a tube mechanically; and rolling a single plate with three separate fuel cores. Methods of making the seam joint were consumable arc welding, non-consumable arc welding, and resistance seam welding. The last appeared the most promising. Mechanical assemblies were also tried, including riveting: and deformation, groove, and link locking. The elements that emerged as the most economical were concentric tubes made of brazed plates; and the riveted and deformation locked assemblies. Both types are used for the first loading of BR-2.

Uranium Tubes

Tubular uranium fuel elements may be fabricated in seven processes which fall into three categories: casting, forming of tubes, and machining to tolerances. Conventional equipment can be used but further development is needed in such processes as horizontal centrifugal casting, Assel Mill forming, Rockrite forming, and Hamiroll swaging. Extrusion processes have been extensively developed but the cost is still affected by butt losses and eccentricity. Machining processes require only some further refinement. (C. E. Polson *et al.*, Nuclear Engineering and Science Conference, V-101.)

Sinterability of Uranium Oxide Powders

In a paper "Sinterability of UO_2 Powder for Fuel Elements," by R. Wrinkle (Nuclear Engineering and Science Conference, paper V-108) various types of powder are compared in cold extrusion and cold pressing procedures. Uranium oxide made from micronised uranium trioxide exhibited the highest sintered density of any powder compact tested. Fuel element grade oxide yielded the lowest density of all. Particle size and surface area of ground powders show some correlation with sintered density. Dimensional variations in extruded rods were definitely larger than in pressed compacts.

Sintered Can and Fuel

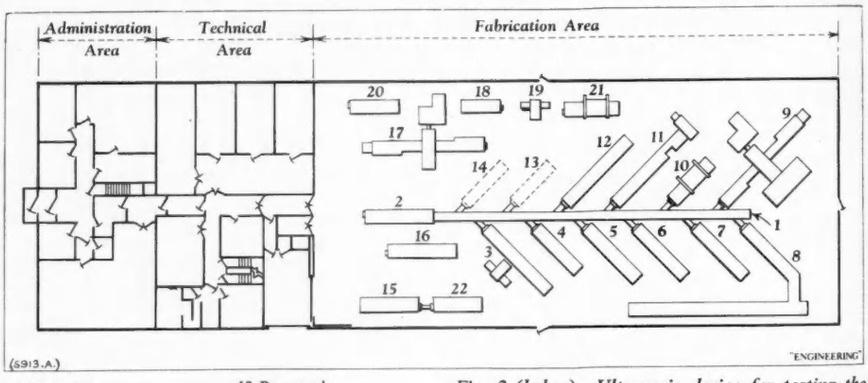
Half-inch diameter fuel tubes can be manufactured out of a sintered "sandwich" of uranium oxide mixed with powdered stainless steel and bonded to two layers of stainless-steel cladding. The heterogeneous board behaves as a single sheet when fabricated and can be formed into tubes. Fuel elements of this type have been used in the Idaho Falls materials testing reactor and a burn-up of 41·7 per cent has been attained. Martin-Nuclear have developed the fabrication method for a new reactor which they are designing for the US Air Force station at Sundance, Wyoming. The pressurised light water reactor will have a rating of 9·3 MW(t) from a core about 30 in long and 23 in diameter. The uranium 235 inventory will be around 60 lb, and the fuel elements are designed for a 33 per cent burn-up in two years of operation.

Ultrasonic Testing

A method of testing the bond between fuel element and can at Hanford is described in "The Use of Ultrasonics in the Testing of Irradiated Fuel Elements," by J. M. Fouts (Nuclear Engineering and Science Conference, paper V-112). A pulse echo technique is used. Signals are generated and detected by a single transducer. At a pulse repetition frequency of 3,000 per second, the element is examined every 0·02 in, giving a testing time of 40 seconds for an 8·9 in long slug. Two discriminators of different setting allow small porosities to be overlooked, so that rejection can be made to certain specifications. The handling equipment for bond testing consists of a manipulator 10 ft under water for rotation of the active slugs. The instrument is shown in Fig. 2.

Forge Rolling Zircaloy

The development of a process for producing recessed Zircaloy cover plates is described in "Forge Rolling Zircaloy Components," by R. D. Johnson, R. J. Gridley and R. L. Clark (Nuclear Engineering and Science Conference, paper V-110). The advantage of the process lies in the reduced material waste compared with machining. With improvements the forge rolling system could reduce scrap losses to 15-20 per cent, but because of tooling costs it could only be competitive with conventional machining methods on a production basis involving more than 2,000 pieces. With the exception of minor defects, the thickness dimensions were controlled to within $\pm$ 0·0015 in. Specific lengths are more difficult but $\pm$ 0·020 in accuracy is hoped. As a result of improved fabrication techniques, zirconium is increasingly used not only as a low capture cross-section material, but also for its resistance to corrosion by acids, alkalis, and organic compounds.



1 Conveyor
2 Introduction and removal
3 Machine shop
4 Electrolysis and aqueous solution
5 Weighing and inspection
6 Centrifugal casting
7 Ingot casting
8 Extrusion press
9 Rolling mill "A"
10 Plate shear
11 Wire fabrication
12 Press work
13 Future line
14 Future line
15 Welding and cladding
16 Decontamination
17 Rolling mill "B"
18 Work bench
19 Milling machine
20 Lathe
21 Plate shear
22 Liquid metal filling

Fig. 1 Fuel fabrication plant for the development and production of plutonium elements at Argonne.

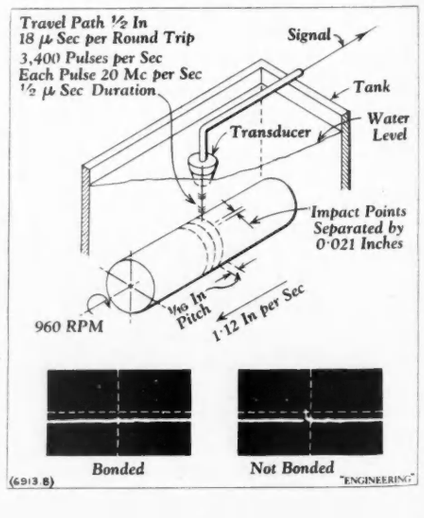


Fig. 2 (below) Ultrasonic device for testing the bond between fuel and can, with the oscillograms.

High Temperature Circulating Fuel

A proposed Flowable Solids Reactor (FSR) is a high-temperature, circulating-fuel, heterogeneous power reactor. The fuel material is a dry, granular solid which flows by gravity through vertical channels in a graphite moderator. Calculations indicate such a system, if practical, could produce power which would be competitive now with conventional steam plants in many areas of the United States. However, the feasibility of such a reactor depends on a number of unknown factors, among the most important of which is the behaviour of the fuel material itself under the contemplated conditions. As a first step in the study of system feasibility, an investigation has been made into the cost, flow characteristics and resistance to thermal shock, impact and radiation damage of certain promising refractory compounds of uranium and thorium. On studying the results obtained, the conclusion was reached that crushed arc-fused UO_2 is the best available material; it is relatively low in cost and has flow and attrition resistance properties such that it appears very promising for use in a Flowable Solids Reactor. (R. C. Oliver, Fluor Corp., Ltd., Whittier, California, *Nuclear Science Abstracts.*)

Stability of Dispersion-Type Fuels

In a dispersion-type nuclear fuel and poison system, the overall dimensional stability of the element under irradiation may be improved by providing void space for the expansion or distortion of the dispersed particles. In "Increasing the Effective Void Space in a Dispersion-Type Nuclear Fuel by Plastic Deformation in Tension," by S. M. Bishop, Knolls Atomic Power Laboratory, Schenectady, New York, it is shown that tensile plastic strain increases the void space around particles of UO_2 imbedded in stainless steel; and that, to a first approximation, the amount of void space is proportional to the amount of plastic strain. It is suggested that a controlled, uniform amount of void space could be produced by tensile elongation prior to the final anneal and assembly into the reactor.

Fuel Slurry News

Tests on experimental loops of uranium-oxide and thorium-oxide slurry indicate that the rate of corrosion is not constant but tends to level off with time. With proper chemical control the corrosion rate can be maintained at 1 to 2 mils per year, which is about the same as the corrosion rate of plain carbon steel in water. Other test loops have been used to check the "pumpability" of slurries with various solid-to-liquid ratios. Present indications are that the major obstacles to the development of aqueous-homogeneous reactor—of which corrosion was one—have now been overcome and development at the joint undertaking of Westinghouse, Pennsylvania Power, and Baltimore Gas, can move from feasibility study to prototype testing.

Critical Test for Fluidised Bed Reactor

Advantages claimed for the liquid fluidised-bed reactor (LFBR) are elimination of control rods and the corresponding invested reactivity, homogeneous burnup, continuous refuelling, improved heat transfer and better plutonium conversion. The nuclear division of Martin Company have received permission to construct a critical facility to try out the idea. Initially, the moderator-cum-suspending liquid will be water, although organic liquids are planned for power production. Fuel will be slightly enriched uranium in aluminium clad pellets approximately ¼ in diameter. Fig. 3 illustrates the principle of operation. Preliminary studies indicate that reactivity is not sensitive to moderator circulation and a relatively broad range of pumping rate will give near-critical conditions. Failure of the circulating pumps shuts down the reactor, but provision must be made against accidental supercriticality resulting from overspeeding of the pumps. One of the fabrication problems Martin-Nuclear will test in the critical experiment will be the rate of abrasion of the fuel elements. Ceramic cladding is a more remote possibility that would improve the reactor's neutron economy.

Lubricant for a Fluidised Bed

Adding powdered graphite to the water moderator of a fluidised-bed reactor (LFBR) reduces the abrasion rate of the fuel pellets by 80 per cent. It is also possible that the presence of powdered graphite will improve the heat-transfer properties of the reactor system, although experimental proof is still missing. The idea of adding a lubricant to the moderator was conceived by two Martin-Nuclear engineers who received an award of $1,000.

Continuous Removal of Fission Products

An improved fuel element and a novel reactor core system has been suggested for facilitating removal of contaminating fission products, as they are formed, from association with the fissile fuel. The fuel elements comprise tubular members impervious to fluids and containing on their interior surfaces a thin layer of fissile material providing a central void. The core structure consists of a number of the tubular fuel elements arranged in parallel and a closed manifold connected to their ends. In the reactor the core structure is dispersed in a water moderator and coolant within a pressure vessel, and connected to the manifold is a device for withdrawing and disposing of mobile fission product contamination from the interior of the fuel tubes and manifold. (W. T. Moore, Patent No. 2,851,409.)

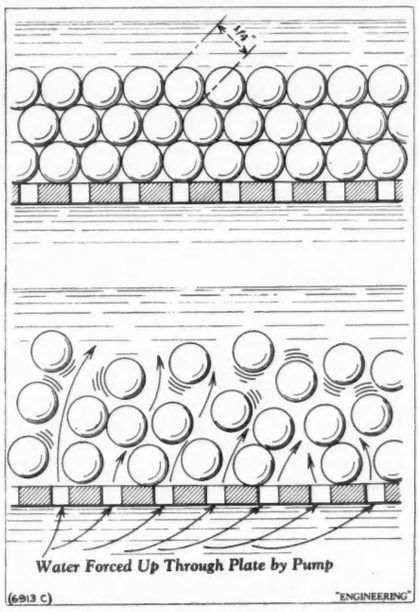


Fig. 3 Liquid fluidised bed reactor shut down (above) and critical (below). Burnup is uniform.

Trombay Plant

A fuel fabrication plant at Trombay, near Bombay, India, should soon go into regular production to supply fuel elements to the Canada-India reactor under construction. Most of the equipment required to fabricate fuel elements has been commissioned and fabrication of a prototype element was completed in July.

Rolls-Royce Plant

An experimental factory is being built at a cost of £1 million by Rolls-Royce at Raynesway, Derby. Fuel elements for the pressurised water reactor of the Royal Navy's second nuclear submarine are to be fabricated there. Material for the elements will be provided by the Springfields and Capenhurst plants of the UKAEA.

Notes and News

Dounreay Critical

After a year's delay, the Dounreay fast breeder reactor went critical on Saturday, 14 November. No public announcement was made in advance, and it is not clear whether all development difficulties previously reported have been overcome. According to one announcement, the reactor will be operated at low power for "some time," after which it will be shut down for inspection and possible modification.

Speeding up the Fast Reactor Programme

Fast reactors have been compared to controlled atomic bombs, not only because the reaction is sustained by fast neutrons, but also because control is often achieved by varying the distance between two subcritical masses of fuel. A new experimental reactor has been commissioned at Argonne National Laboratory using the "bomb" method of control Criticality in the Argonne Fast Source-Reactor (AFSR) was reached with a uranium 235 mass of 21·28 kg on 29 October. The fuel is in the form of thin discs 4½ in diameter in a nickel sheath. The two fuel masses are above each other, the lower half being movable. A breeder blanket of uranium 238 surrounds the core, leaving room for three experimental channels for fast neutrons and a graphite thermal column. The neutron flux is 570×10^9 neutrons per second per sq. cm and will be used to measure the energy spectrum of neutrons in a fast reactor. In an emergency the reactor may be quickly shut down by the removal of two safety plugs of blanket material to reduce the amount of reflection. The new reactor will supplement the existing zero-power fast-neutron facility ZPR-3 and the two experimental breeder reactors EBR-1 and 2.

Lean Years for Canadian Uranium Mills

A serious gap in uranium purchases is threatening the continuous operation of Canadian uranium mills. Purchases by the United States for military purposes will terminate in 1962-63 (Atomic Review, 13 Nov., '59) at a time when civilian demand for fissile material will be much less than world productive capacity. The Canadian Government expects civilian demand to catch up by 1966, and it is faced with the problem of ensuring the survival of the uranium industry until that date. Negotiations with the USAEC and the UKAEA have resulted in a plan to stretch out present commitments to 1966. In addition, about half of the mining capacity will have to be shut down towards the end of this year and considerable realignment within the industry is expected. It is hoped that no mining area will be completely closed as a result of the cut-back, but the smaller producers will find it difficult to survive the lean years.

Expandable or Expendable UKAEA?

Membership of the Atomic Energy Authority will be increased from 10 to 15 according to a Government bill introduced recently. The authority shows signs of severe Parkinson growth; it is hoped that its structure will be able to resist the stress—without annealing.

Dresden Under Commissioning

Only five years after the first experimental boiling water facility was operated at the Argonne Laboratories, a commercial power producing reactor is now undergoing commissioning trials in Dresden, Illinois. The speed of development is remarkable considering the temerity with which the boiling-water proposals were approached initially. The first tests with Borax-1 in 1954 proved that the design was safe, and in later experiments with the Borax series the power rating originally expected was exceeded by a wide margin. It was found possible to increase the original rating of the 5 MW(e) experimental reactor EBWR by a factor of three without any major structural changes. EBWR was followed by the General Electric test reactor at Vallecitos, and finally the full scale 180 MW(e) power station at Dresden. Many other stations have been designed since, among them the 150 MW(e) SENN installation for Italy, now under construction, and the 22 MW(e) Elk River plant in Minnesota.

Italy: Proving Ground for Power Reactors

Simultaneous construction of three different types of power reactor in Italy by industrial concerns of two countries—UK and USA—will provide an unparallelled opportunity for the comparison of construction costs. So far, comparisons have suffered from the complicated transposition of data that is necessary to reduce construction costs from widely differing economies to a common basis. The American General Electric's boiling-water reactor and the British NPPC's gas-cooled reactor are both located in Southern Italy in the Rome-Naples area, and only the Westinghouse pressurised-water reactor will be built in an area—Northern Italy—where labour costs, particularly that of unskilled labour, might show a significant difference. It is certain that developments in Italy will be keenly watched by all parties interested in nuclear power, and it may well happen that the future of the gas-cooled reactor as an export commodity will be decided there. In this light it is very unfortunate that NPPC are reported to have encountered difficulties with AGIP Nucleare, the state-owned concern who have commissioned construction of the station. The *Financial Times* indicated that the difficulties are of a financial nature, and that representatives of NPPC will go to Rome this month to discuss the matter with Enrico Mattei, president of the group of state-owned companies which control AGIP Nucleare.

Aerial Highwaymen Tap Mineral Wealth

Antarctica and other unexploited areas may one day be the source of mineral riches. Mineral deposits must first be found; but equally important is the discovery of routes to carry them away. Aerial surveying can perform the second task as neatly as the first.

It was in 1640 that the Swedish Chancellor, Axel Oxelstierna, made what is believed to be the first reference to use of magnetic surveying for location of iron ores. Not much is known about the methods which his prospectors used, but one thing is certain—they were not airborne. Nowadays there are 45 companies involved in photogrammetric surveying and geophysical exploration—half of these having been founded in the last five years. The explorer's days are not over, however. There is still need for the backing of land-operating groups to take samples of rock and ore and generally to confirm the hunches of the photogrammetrist as to what the different tones on his photographic mosaic represent. With aerial methods there is not quite so much wading through swamps, and climbing over mountain passes.

Aerial surveying helps our exploitation of minerals in two ways: first it enables minerals to be located, but just as important, it provides a quick, economical method of finding out where to put the highways required to move them. Fly at 20,000 ft and analyse the films stereographically in a "first order" reading machine, and it is possible to draw contours with an accuracy of about 3 ft; on quicker, "third order" equipment—to about 20 ft. Combining this information with more obvious details such as watercourses, areas of forest, rocky mountains or grand canyons allows preliminary fixing of road routes. Come down to 2,000 ft and perform a low-level survey perhaps using Airborne Profile Recording apparatus and infra-red photography, and the civil engineer can be given an accurate picture of what soil he has to move, where bridges are demanded, and where there are sources of gravel and rock which he can use in highway building.

BABYLONIAN SCRATCHINGS

It would be naive to say that mapping is in its infancy; but it is certainly not true that maps of all parts of the world can be bought "round at the local stationers"; the Babylonians were busy in 2,500 BC scratching maps of their circular world on clay slabs, but even last year, 1958, it was reckoned that no less than 84 per cent of the world's land surface was unmapped except at scales smaller than 1:75,000, and for 35 per cent no maps existed at all. There is now the strange situation in which the Ordnance Survey in Great Britain is completing the task of putting accurate 5 ft contours on existing 25-inch-to-the-mile maps (Britain started way back in 1791), while a private company has just performed a high level survey of Ethiopia to determine where the first roads could be laid down for expansion of the country.

Techniques for both mineral surveying and map making have improved greatly since the Second World War. Although information for both activities is obtained from the analysis of aerial mosaics compiled from overlapping pictures taken on parallel traverses of terrain, the niceties of geophysics are really a science on their own. Basically, the detection of ore deposits, or rocks, and by implication, oil, depends on measurement of changes in magnetic properties, electrical conductivity or radioactivity. Firms who undertake such work will hasten to add, moreover, that the analysis of the traces is "not easy."

Present day magnetometers can detect changes in the earth's magnetic field of the order of $1\text{-}2 \times 10^{-5}$ Gauss, the actual field being $20{,}000 \times 10^{-5}$ at the equator and about $70{,}000 \times 10^{-5}$ Gauss at the poles; iron and titanium ores are detected in this way and the presence of oil implied by association with the accompanying rock structures. Even greater sensitivity is offered by equipment developed in the United Kingdom which makes use of nuclear resonance phenomena.

TRAILING BIRDS

Conductive ores such as copper, nickel, iron, and lead-zinc sulphides, and such substances as gravels, clays, water and coal, are shown up by electromagnetic analysis. The standard method has been for a low flying aircraft, usually at a maximum of 500 ft, to fly over the terrain trailing a "bird." This detects changes in intensity and phase of an electromagnetic field which is generated and transmitted from the belly of the aircraft. Two transmitting requencies are jointly employed, 2,300 and 400 c/s. Penetration of the higher frequency is not so deep and shows up lakes, swamps and surface structures; the lower frequency shows up hidden deposits. The drawback in using birds is that signal detection is more sensitive the further they are from the source of transmission, and even a trailing distance of 500 ft creates trouble in turbulent weather conditions. One solution has been found in the use of two aircraft, the first trailing a bird at 80-100 ft distance, and the following aircraft transmitting the electromagnetic signal from 800-1,000 ft behind. This method was successfully used in East Africa employing two de Havilland Rapides. Their distance of approach must be kept constant as must their height from the ground, the allowable variation in the latter being about 25 per cent.

Scintillation counters are used for radioactive deposit surveys. Ores which fall into this category include uranium, radium and thorium, and they have great difficulty in remaining unobserved—for a typical counter of two years ago could detect a deposit of radium of the order of 35×10^{-6} oz in magnitude.

MOSAICS LACK CONTOURS

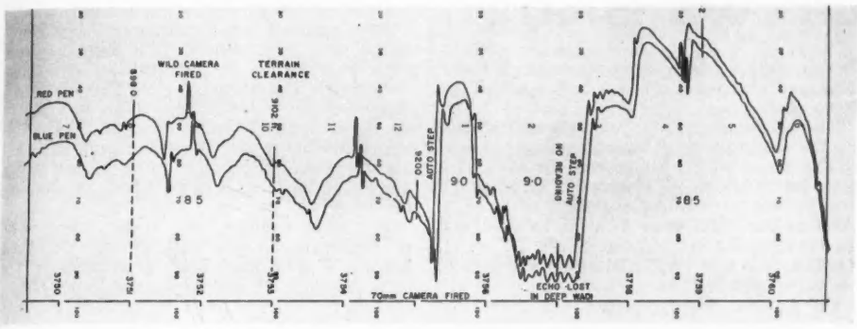
Now to advances in surveying: surveying to provide maps and mosaics. The first of these is made from the second by processing in a variety of equipment, but the provision of a straight mosaic is by far the cheapest operation. What are lacking on a mosaic, of course, are contours, but this is partly offset by the photographic modelling and shadowing which results from the topography of the land. A variety of machines is available to the photogrammetrist, and as has been implied before, these are known as of first, second or third order. These categories reflect the capability of the machine to discern topographical contours, when used to analyse overlapping photographs stereoscopically. In an inverse sense it reflects the speed at which the operation of mosaic-to-map may be carried out. In the first order the Wild A5 and A6 Autographs, the Zeiss 68, the Santoni Stereocartograph, and the British developed Thompson Watt Plotter are generally considered to fall; these allow a vertical reading accuracy of 1/5,000-1/8,000 of the flying height. Second order machines allow of 1/2,000-1/5,000, that is, of 10-4 ft in 20,000 ft; and third order machines allow of 1/500-1/2,000.

(Left) A Tellurometer for ground surveying has an accuracy of 2 in over 35 miles.

(Below) Burning tree is an aerial photograph of the Colorado Delta from 13,800 ft.

Special Article

When accurate contours are required the obvious course of action is to reduce the flying height, but while the vertical resolution decreases linearly, the number of exposures required to cover a given area increases as the square. It is not surprising, therefore, that although aerial surveying shows economies of the order of 50 per cent over a complete ground survey, the companies involved are pushing ahead to increase the resolving power of photographic emulsions, camera lenses and stereo-analysers, so that accurate maps can be taken at higher speeds at greater heights. Mr. W. P. Smith, M.B.E., in giving yesterday's Fifteenth British Commonwealth Lecture to the Royal Aeronautical Society, quoted figures to illustrate the advances in resolving power: the Second World War standard of making a map of 1 : 30,000 scale by flying at 15,000 ft which involved 7,800 exposures in a flying distance of 13,400 miles, can now be replaced by the more generally accepted scale of 1 : 40,000 by flying at 20,000 ft and taking only



(Above) A trace from the Airborne Profile Recorder with constant aircraft height.

(Right) Modern stereoplotters for taking contours from film are complex in design.

(Lower right) Information such as this can be of great interest to the highway builder.

4,360 exposures in a flying distance of 10,000 miles. The most important step forward since 1946, he says, has been the introduction of a new type of survey lens typified by the Aviogon 150 mm objective made by Wild of Switzerland. The lens resolving power of such lenses is better than 50 lines per mm on the axis, there is very low distortion, better and more even illumination, and wide angle coverage of about 90°. Newer still is the super wide angle lens called the Super Aviogon, which has an angular coverage of 120°. The advantages of these are being backed up by improvements in photographic emulsions which suffer less than 0·03 per cent differential distortion, in cartographic tracing and photographic papers, in camera mountings and even in the survey aircraft themselves.

On this latter subject it is almost a misnomer to talk of a " survey aircraft " for there is only one, the Survey Prince, which was especially designed for the job of survey work. Those most commonly used include B-17's, Dakotas, Mosquitos, Doves and Lodestars, and none has a speed over 200 knots or is equipped for continuous flying above 30,000 ft. The ideal aircraft is thought to be one which can fly for long periods at 30,000 ft, will carry a payload of 5,000 lb, has a range of 1,700 nautical miles and has good forward and vertical visibility. Dart Heralds, Fokker Friendships, and the Lockheed JetStar satisfy the requirements, but their use is prohibited for present privately owned survey companies primarily on the ground of first cost. In the services these considerations are not so poignant: 1955 saw the RAF mapping Aden Protectorate and Northern Kenya with an English Electric Canberra, the Canadian RCAF have used Lancasters, and the USAF have recently modified a Lockheed C130 turboprop aircraft.

GROUND ACCURACY

To the man on the ground, one of the greatest aids to accurate surveying has been introduction of the Tellurometer in 1954. One of these is shown being operated in the large-scale mapping of Ethiopia. They operate on radio frequencies and offer the frightening accuracy of 2 in on distances up to 35 miles. Since they are unaffected by fog, cloud, rain or cold, it remains only to ensure that there are no friendly hippos around and that the operator himself doesn't get cold feet.

While British Railways are employing aerial survey companies to sort out their sidings and Canadians are busy in Baffin Land, there is another project which has rather caught the public imagination—exploiting the minerals in Antarctica. Mind you, they haven't been found yet. In 1956-57 a British firm used Canso amphibian aircraft to photograph 35,000 sq. miles in the Graham Land Peninsula and in 1959-60 the Australian authorities intend using the latest super wide angle lenses in a survey. American attitude to an Antarctic survey, as reflected in their proposals submitted to the Special Committee on Antarctic Research at Canberra, Australia, this last March, seems to be: the Antarctic is a mighty large place and what is wanted is an overall mapping survey at a scale of 1/2,500,000 which can be performed from a height of 50,000 ft at speed. They suggest flying in traverses 45 miles apart using an inertial navigation system and Aerial Profile Recording. If minerals are proven, such maps will be vital for their exploitation.

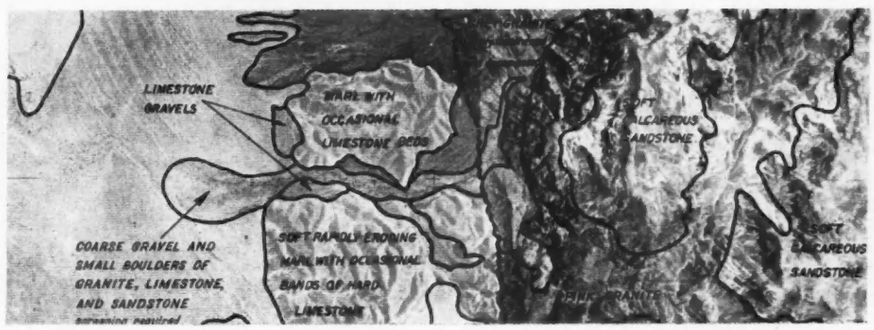
Any list of the major mineral discoveries which have been made by aerial surveying would soon become pretty long. Certainly it would include the two outstanding ones, both made in recent years. First, over to Norway: here a mining concern gave a contract for an aeromagnetic survey of 300 sq. miles of fiord country, which after three weeks with the magnetometer unearthed a hidden deposit of 200 million tons of ilmenite. Then, in the Philippines, where 8 million tons of iron ore were discovered after a similar short time. There have been surveys for radioactive ores in Devon and Cornwall, for pyrites in Spain, and base metals in Australia.

WHEREWITHAL FOR HIGHWAYS

In building roads, the aerial survey can be of great help to the civil engineer. Use of the Airborne Profile Recorder, which gives a trace such as the one illustrated, gives a very accurate picture of surface contours: this, when coupled with an interpreted mosaic showing the nearby gravel, rock and sand deposits, makes the planning of materials movements a very straight forward job, even when planning a road to get the ground nuts out of Nigeria, a project, incidentally, which was undertaken.

The future for aerial surveying looks bright. Even if present underdeveloped countries operate their own aircraft, and work is taken from the international companies, the actual amount of surveying is unlikely to decrease. First maps become out of date and need revising: communities grow and establish new towns, all requiring the services of the aerial surveyor.

Unlike the explorer who centuries ago lost himself in the Colorado Delta, the modern surveyor is equipped with his APR and his Doppler Navigator to go out in the early morning sun and make best use of the light before clouds come, and to know just where he is in the middle of the Sahara Desert. Antarctica, Baffin Land, and the wild woods of Borneo no longer fill him with awe, only inspire him to find new deposits, and to find some way of getting them out to a world population which is crying out for a higher standard of living and more room to breathe.


LIMESTONE GRAVELS
MARL WITH OCCASIONAL LIMESTONE BEDS
COARSE GRAVEL AND SMALL BOULDERS OF GRANITE, LIMESTONE, AND SANDSTONE
SOFT RAPIDLY ERODING MARL WITH OCCASIONAL BANDS OF HARD LIMESTONE
SOFT CALCAREOUS SANDSTONE

Acknowledgement is made of the kind assistance in preparing this article, provided by United Aircraft Corporation and Fairchild Aerial Surveys in the USA, and of Fairey Aviation Company, the Hunting Group of Companies and the Royal Aeronautical Society in the United Kindom.

Swan River Narrows Bridge

Of prestressed concrete the bridge has many notable features: piles allowing ground movements; precast concrete I-segments for main beams; external cables eliminating ducting; vertical shear cables; and method of obtaining continuity at construction hinges.

The Swan River Narrows bridge at Perth, Western Australia, is the largest precast prestressed concrete continuous beam bridge at present in existence, and the central span of 320 ft is the longest single span yet built in concrete to the design of a British engineer. It has been built to link a rapidly expanding suburban area on the south side of the River Swan to the main part of the city on the north side. The site selected is where a jutting promontory from the south bank reduces the river width to 700 ft. The site is also well suited to the traffic requirements.

Between the faces of abutments the length of the bridge is 1,100 ft; the carriageway is 70 ft wide, providing six traffic lanes. There are 8 ft wide footpaths on each side, separated from the carriageway by a 2 ft wide safety kerb and fence. The headroom specified for river traffic in the navigation channel was 26 ft and for road traffic on the riverside roads was 15 ft. The maximum road gradient is 3½ per cent.

The bridge is designed on the basis of British Standard 153 and special vehicles of 75 tons. It also carries five 30 in diameter pipes for water and sewage, gas mains, electric and telephone cables.

There are five spans—of 160 ft, 230 ft, 320 ft, 230 ft and 160 ft—designed to be fully continuous under live load. The bridge is achored at the north abutment and all expansion movement is provided for at the south abutment. Construction was eased as it was possible to erect staging across most of the river to support the precast segments before the cables were stressed.

The bridge is founded on long piles—180 in number—which support abutments and piers of reinforced concrete. Above the piers reinforced concrete rocking columns carry the deck structure of prestressed concrete.

To achieve the pleasing appearance, precast concrete facing panels have been used along the outer faces of the parapet beams. These panels are made from crushed white quartzite aggregate, white sand, and white cement, and the aggregate has been exposed on the surface to give a light rough, highly reflective surface. The abutments also are constructed in white concrete, as are the cantilever structures forming the footpaths. The balustrades are of aluminium set in granite and the carriageway is flanked by polished granite pilasters at each end of the bridge, which carry commemorative plaques Anodised aluminium has also been used for the lamp posts.

The carriageway is topped with asphalt laid by the Department of Main Roads.

The design of the bridge was the work of a team led by Mr. G. A. Maunsell of G. Maunsell and Partners, consulting engineers, of London. Also in the team were William Holford and Partners, consulting architects; Mr. E. W. H. Gifford, who was responsible for the design of the prestressed concrete superstructure; and Mr. C. S. Chettoe, formerly bridge engineer to the Ministry of Transport in the United Kingdom.

Tenders were called for in February, 1957, and the contract was awarded to Christiani and Nielsen, of Copenhagen, in association with J. O. Clough and Son Pty., Limited, of Perth.

The piles, of a type invented by Mr. Maunsell and known as "Gambia piles," consist of 31½ in outside diameter steel tubes with ⅜ in thick walls and having a steel toe. Reinforced concrete was placed in the toe of each pile for a depth of 15 ft prior to driving, which was carried out by means of a 10 ton drop hammer working inside the pile against a removable driving helmet lying on the concrete in the toe. Extensions to the steel tubes were welded on during driving. The piles were driven through sands, silts, gravels and clays to be founded on very hard clay overlying a stratum of limestone. After driving, the tubes were filled with reinforced concrete; corrosion of the outer steel tube is not a danger to the structure, since the design takes account only of the reinforced concrete core.

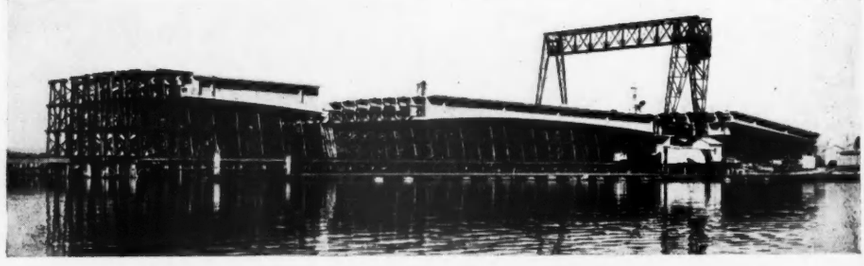
The piles have been designed to carry maximum dead loads of 200 tons each, increased to 250 tons by transient loads. Test loads of 400 tons were carried without measurable permanent deflection being recorded, and the piles are thought capable of carrying more than 600 tons.

Under the north shore pier the piles were of a modified design to allow for possible movements in the reclaimed ground through which they were driven. The top 60 ft of the pile consists of a precast reinforced concrete column placed inside a 48 in diameter steel shell after driving. The space between the two permits deflection with ground movement of the steel shell, which is weak in bending, without transmission of the deflection to the precast concrete column supporting the bridge pier.

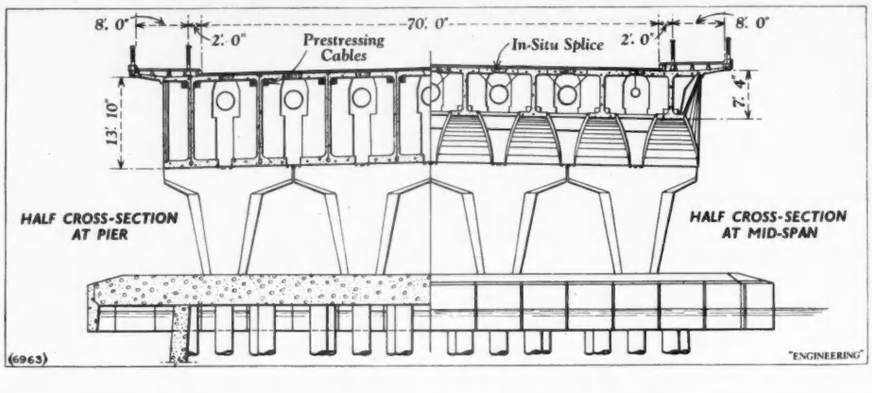
The abutments are of conventional box form, except that a suspended slab supported on internal walls is incorporated to overcome settlement. The shore piers are also of simple design—of reinforced concrete set in the ground; for the river piers, precast concrete skirt pieces were employed as permanent formwork so enabling the structural concrete to be placed in the dry, and to avoid exposing the piles to view during low water.

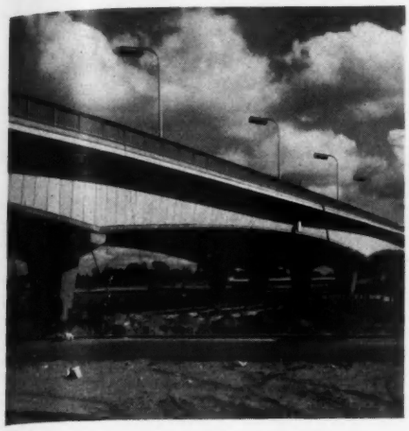
The bridge columns, four to each pier, are of reinforced concrete and each supports two deck beams. Curved steel bearing plates carry the columns which are surmounted by similar plates, so that the columns form large roller bearings which permit up to 7 in of longitudinal movement of the bridge to take place with the minimum of frictional resistance. Transverse expansion and contraction is provided for by nests of 7 in diameter roller bearings set in boxes in the concrete under three of the columns on each pier. The boxes have been filled with tar to prevent corrosion and the entry of rubbish and water. All bearing surfaces, which have been left dry, are of stainless steel.

The beams of the deck structure are made up of precast I-units which were jointed and stressed together in position above staging. Though designed to act as double-cantilever beams with suspended spans during erection, the bridge as



(Above) Deck erection above staging across the river. *(Below) Cross-section of the bridge.*



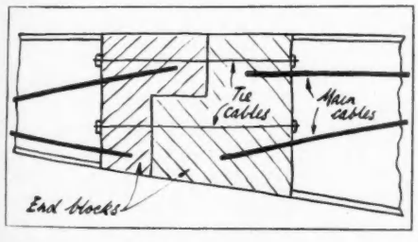


Exposed aggregate fascia panels, aluminium balustrade and lamp posts.

finished is continuous over all five of the spans.

Features of the deck superstructure are the external cables, the vertical shear cables, the method of casting the precast concrete segments, and the method of obtaining continuity.

By putting the main cables outside the concrete section, it has been possible to keep the thickness of both the web and flanges down to 8 in, sufficient only for the vertical prestressing cables and the local mild steel reinforcement. To achieve maximum eccentricity of the prestressing forces the cables have been kept particularly compact. Each cable is a 19-wire strand of 0·7 in diameter used with split wedge anchor grips. At the points where the cables change direction they pass over lubricated machined steel saddles; the loss of prestress was only 4 per cent, or one-fifth of the value usually associated with long curved cables in ducts. The prestressing forces were accurately measured with load cells reading on mirror galvanometers. After completion of tensioning, the cables were surrounded with fine concrete to protect them from corrosion and to bond them to the beam through mild steel shear bars which were passed through holes in the webs.



Developing continuity at the temporary construction hinges.

Vertical prestressing cables were used to reduce the principal tensile stresses due to shear in the thin webs, but as these cables were not sufficient alone to resist the total shear tensions at ultimate load, additional mild steel reinforcement was added. Because of the lack of fundamental information on the behaviour of prestressed concrete beams in combined bending and shear, a one-third scale model was made to verify the assumptions made in the design. The model failed close to the predicted load, which had been calculated on the assumption that the shear forces would work as in a lattice beam, and that the main cable was fully bonded. The load factor was 1·95 on the dead plus superimposed load; the factor can also be expressed as 1·5 on the dead load plus 4·4 on the superimposed load.

Because, in the designer's opinion, beams of the required cross-section were unsuitable for *in situ* construction, the bridge was built with short precast segments with separate diaphragms. To further simplify the construction, the beams were detailed so that the bottom flange and lower section of the web were cast first. A few days later, the remainder of the section was cast in a second mould, bolted to the lower part of the web; the second mould could thus be of standard shape, and the variable depth of web and width of bottom flange were both accommodated in the first stage of casting. A minimum 28 day strength of 6,500 lb per sq. in on 6 in cubes was specified, but this was easily exceeded. The units were transported from the precasting yard to the bridge on a light railway from which they were lifted by a Goliath travelling crane on to a staging of local Jarrah poles.

After a full length of the staging had been loaded with units, adjustments were made for line and level using small screw jacks, but leaving 3 in wide gaps between the sections. The gaps were filled with fine concrete compacted with immersion vibrators.

The primary strands of the main cables of the double-cantilever beams were then threaded and stressed. To give access to the beam ends for cable tensioning, the suspended spans were constructed above their final position. After completion they were jacked down until the halved ends of the anchor blocks mated with those of the double cantilever beams; neoprene pads were left between the mating faces. The temporary props which had been left beneath the centres of the beams were then removed, and the secondary main cables were tensioned. These cables have their anchorages in the top flange of the main beam.

After the transverse cables had been tensioned and the *in situ* concrete deck splicing strips placed, the precast fascia panels were erected, and the cantilever footway slab concreted.

The final operation to complete the superstructure was to make the beams continuous by locking the temporary hinges. This was done by caulking the vertical joints between the anchor block faces with cement mortar and then clamping them together by stressing short cables passing through ducts in the anchor blocks and overlapping the main strand cables, thus giving complete continuity.

As a guide for future designs, the equivalent concrete slab thickness for the total concrete used in the deck structure is 23 in. The total cost of the bridge, expressed as a cost per square foot of gross area of the deck and abutments, is £11 15*s*.

Possibilities for Nile Valley

When Egypt starts to store water behind the new Aswan dam in about 1964, the Sudan will be entitled to one-third of the total annual flow of the Nile, instead of one-twelfth as at the present. This is the principal point in the agreement that has been reached between the Sudan and United Arab Republic concerning the sharing of the Nile waters. Egypt is also to pay compensation for the Sudanese who will have to be moved as the water backs up behind the new dam.

A most important outcome of the agreement is the clearance it could give towards a new dam on the Blue Nile at Rosieres in the Sudan; this would enable the expansion of the Gezira cotton fields. The two states have also agreed to share the cost of the Upper Nile projects, including the Jonglei canal system which will increase the overall flow by reducing evaporation in the marshy areas of the Sudd region. Unfortunately, the other riparian states—Kenya, Uganda, Tanganyika, Ethiopia and the Belgian Congo—were not represented at the meetings when the agreements were reached, so that a truly comprehensive settlement of the Nile problem was hardly possible.

How the Nile and all its tributaries should be controlled to provide the maximum amount of water for irrigation was the subject of a paper read at the Institution of Civil Engineers on 10 November. The authors were Mr. H. A. W. Morrice, irrigation advisor to the Colonial Office, and Mr. W. N. Allan, irrigation consultant to the Sudan, who based their paper solely on hydrological considerations, ignoring economic factors. Using a computer, the authors have been able to take into account the vast amount of data that was collected during the period 1905 to 1952. The result is a plan for the Nile that gives maxima and minima for contents of possible reservoirs and the controlled discharges; evaporation; water available for irrigation; and figures for hydroelectric power.

The paper gives in great detail both the data used and the figures calculated for the Nile. It also sets out in full the computer programme which could be adapted without serious difficulty for other rivers.

Durability of Natural Timbers

A field service test being carried out by the Forest Products Research Laboratory to determine the durability of untreated timber is the subject of FPR Record No. 30, *The Natural Durability of Timber*, which is published by the Stationery Office, price 2*s*.

The report summarises the results found so far for 130 specimens which have been under test for the last 25 years. A durability classification of five grades has been prepared and some suggestions are made for its use. As is made clear in the report, treated woods can outlast natural woods and the chief use of the classification is to indicate when and for how long it is safe to use timber in its natural state; in addition, the environment must always be taken into account.

Traffic Study Group formed at I.C.E.

The Institution of Civil Engineers has formed a Traffic Engineering Study Group. Formation of the group has followed a discussion held last March on the position of traffic engineering in the Institution's activities.

Membership of the group, which is open to both non-members as well as members, now stands at 458 of whom 118 are non-members. Between now and the end of the session, five meetings have so far been arranged, when papers will be read and discussed.

Two Films About Bricks

Two new films dealing with bricks have been made by the Building Research Station, Garston, Hertfordshire. They are entitled "The New V-Brick" and "Packaged Bricks at the Brickworks." Both films are to be shown at the London Building Centre and on the stand of the Department of Industrial and Scientific Research at the London Building Exhibition at Olympia.

Both films will shortly be available for free loan from the Films Officer, Ministry of Works, Abell House, John Islip Street, London, SW1.

Six County Water Grid

A proposal for a six-county water grid has been accepted in principle by the Mid-Northamptonshire Water Board. The scheme is part of the full development of the water resources of the Great Ouse. At a cost of £11,500,000, provision will be made for the extra water likely to be required by Bedfordshire, Buckinghamshire, Cambridgeshire, Hertfordshire, Huntingdonshire and Northamptonshire during the next 40 years.

A new reservoir with a storage capacity of 14,000 million gallons (51,000 acre-ft) would be constructed at Diddington, Huntingdonshire.

High Development Costs Hit Luxury Cars

Luxury car manufacturers in Britain and elsewhere are facing increasing competition from the mass-produced car, which is steadily improving in design. As development costs continue to rise, it may be that the mass-producer will take the lead in making design improvements.

By Gordon Wilkins

Throughout the world the reduction in the number of car manufacturers producing the higher priced models has focused attention on the dilemma that faces them; the cheap car is rapidly improving and the cost of designing and developing something very much better has become prohibitive for those with only a small output. In France the most famous names have withdrawn, leaving the field to Facel, a post-war newcomer. In Germany, the financial difficulties of BMW follow a familiar pattern and in Italy Alfa Romeo have been glad to take the opportunity of assembling the Renault Dauphine. The few remaining high-priced makes in the United States, though able to draw on group research and development facilities, find that their share of the market is dwindling.

In England, makers of quality cars can spend more on inspection and on more careful selection of components, but in trying to convey a visual impression of quality they have to fall back on plentiful use of woodwork and leather. Rolls-Royce is practically the only British manufacturer able to obtain a quiet solenoid-engaged starter; the rest make do with noisy inertia engagement, which has long been abandoned on even the cheapest cars elsewhere. Money apparently cannot buy a British-made car radio equal to the best made abroad; it certainly cannot produce one with the popular station-seeking feature. The problem also extends to lamps and instruments; hence the use of a tail lamp from an obsolete Humber Hawk on a Continental Bentley and an Aston Martin. It takes a group the size of Chrysler to pioneer a practical advance like a translucent speedometer scale projecting into the lower edge of the windscreen, where the driver can see it with the minimum deflection of the eyes. The same apparently applies to electrically controlled push-button window lifts which are commonplace on American cars, but cost the buyer of a Rolls-Royce about £90 extra.

The problem is the familiar one of prohibitive design, development and tooling costs where small outputs are concerned. But it does not wholly explain backwardness in such matters as seat design. The reclining, fully adjustable backrest, found on many cheap Continental cars, is a rarity here. Where available, it is mainly through the use of the German Reutter fitting which to quote one example involves the purchaser of a Humber Super Snipe in an extra payment of £52 10*s* including tax. The reasons quoted above deprive buyers of the higher-priced specialist cars of such amenities as the power-assisted sliding seat. But it does not cost nearly so much to experiment with a swivelling seat, which can greatly ease the problem of entering and leaving low-built cars. The 1960 Chryslers have one which is spring-assisted and released by a catch tripped by a cable connected to the door hinge. When the door is opened, the seat swings sideways.

The buyer of the European high-cost car is also deprived of such electronic gadgets as the automatic headlamp dipper, or the self-dipping anti-dazzle driving mirror, both of which are now available with adjustable sensitivity. Nor can he hope to have vacuum operated door locks as protection against being ejected in a crash.

However, there is one essential aspect of comfort in which the European car now leads; this is in the reassertion of size and particularly of height as necessary elements of comfort. The Rolls-Royce and Bentley range, in particular the new Phantom V, orders for which have exceeded all expectations, illustrate the point. The inevitable tooling delays have helped to protect us from following the fashion of the United States where unwieldy cars have colossal luggage trunks but compress their passengers within short, low compartments dictated by the stylists' ideas of a fashionable outline. A low silhouette is obviously necessary for a sports coupé where the aim is maximum performance but it is intolerable for a woman in an elegant evening gown to have to trail it on the ground while squirming into an excessively low-built saloon. The Armstrong Siddeleys, Daimlers, Humbers, and the new six-cylinder cars from the British Motor Corporation show that a reasonable height not only assures adequate headroom; it permits a reasonably high seat and floor level which makes entry easier and gives a much better all-round view.

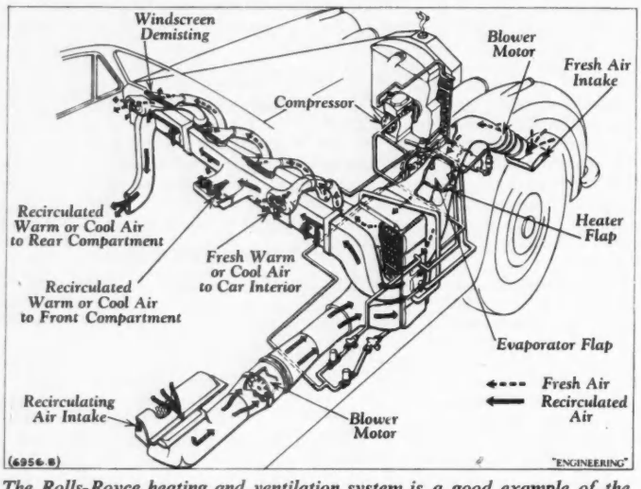
One department in which it seems possible for the small-output manufacturer to make useful progress is in heating and ventilation. The Rolls-Royce system is a particularly good example. Even when the engine-driven compressor, the condenser and evaporators are added for full air conditioning, full control of air temperature, airflow and distribution is obtained by only two fiddle-type switches, which have combined rotary and push-pull movement.

Freon 12 is used in the refrigerator circuit and the compressor is driven via a magnetic clutch which allows it to be stopped when not required. Evaporators and heat exchanger are concealed in the right-hand front wing, leaving the luggage trunk unobstructed. Fig. 1 shows the two air circulation systems. Fresh air is drawn from the front where there is a vacuum-controlled valve and a fan to provide low-speed assistance. Apart from the usual demister slots there are two outlets on the instrument panel with adjustable shutters which allow air to be directed to the face or to demist the side windows. Where refrigeration is provided, there is also a pullout duct which sends cool air up to the roof and over towards the heads of the rear passengers.

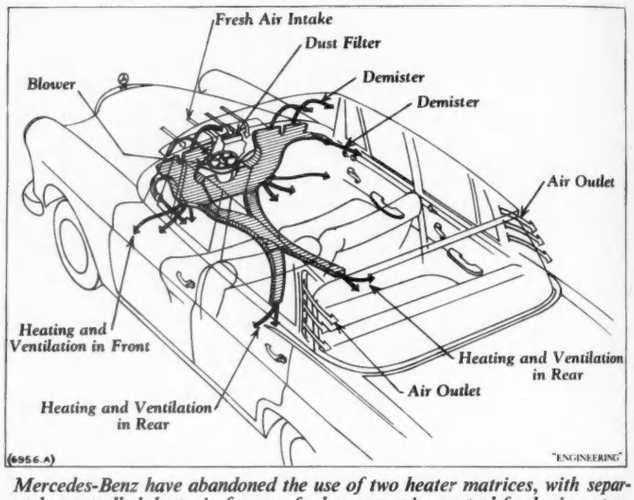
There is also a recirculatory air system which provides for very rapid warming up. This takes air through the duct near the floor of the rear compartment, passes it through a nylon filter and sends it through the heater and back through the evaporator, to be heated or cooled as required.

The pivoted ventilation window has apparently had its day as no one has ever devised a completely effective way of keeping rain out if it is opened in wet weather. If fitted on front and rear doors and pivoted anywhere but at the extreme edge of the pane, it usually involved a liability to pay royalties to the Ternstedt Division of General Motors. Efforts are now being made to take air in at the front and distribute it without draughts. The 3-litre Rover has outlets at the lower corners of the windscreen with controllable louvres to direct the airflow. Plastic louvres over the main windows allow them to be opened slightly without admitting rain or draughts.

On the 220 series, Mercedes-Benz have abandoned the use of two heater matrices with separately controllable ducts in favour of a central heater supplied with fresh air from a scuttle intake. There are the usual nozzles to demist the side windows and underfloor ducts take warm air to the feet of the rear passengers. Vertical louvres are incorporated in the rear quarter panels of the body to act as air extractors.



The Rolls-Royce heating and ventilation system is a good example of the design progress made by the quality car manufacturer.



Mercedes-Benz have abandoned the use of two heater matrices, with separately controlled ducts, in favour of a less expensive central fresh-air system.

Computers to the Fore

Orders for new computers are beginning to come in at a better rate, still far too low to enable leading makers to recoup their considerable investment in research, but encouraging nonetheless. The decisive influence of computers in reducing the costs of United States electrical machinery manufacturers is described in another note on this page (Competitor with a Computer). In Britain labour costs, and particularly the cost of engineer designers and machine tool setters, remain so low as to limit the very large investment involved. Nonetheless, the applications for computers are increasing and rising labour costs must sooner or later impose the electronic solution on heavy plant makers.

The latest order to be announced for a large general purpose computer, in this case costing over £½ million, has been placed by the Ministry of Pensions and National Insurance with EMI Electronics. It is for an Emidec 2400 all-transistor computer which will process data relating to the 25 million persons included in the new graduated pensions scheme. The first of these machines was ordered by the Royal Ordnance Corporation. Last September Ferranti were given a contract by Manchester University to supply, at the cost of about £1 million, a digital computer—to be known as Atlas—which will be many times faster than any computer at present made in Europe.

Several large orders have been secured by the leading computer firms this year. EMI Electronics sold machines, most of them Emidec 1100, to Kodak, Barclay's Bank, the Ministry of Labour and the Air Ministry. Kodak will use their computer for statistical analysis and invoicing, but they also intend to use it to develop production planning techniques. Elliott Brothers (London) have sold well over half a million pounds worth of their Elliott 803 machine. One of their 802 computers—a transistorised general purpose machine—was ordered recently by the Russian Government and another by the Belgian Ministry of Works.

The Rise of Renault

The results obtained by the leading French vehicle manufacturer, La Regie Renault, during 1958, are the best so far. They are one of the very few companies, in their own country or anywhere else in the world, who have wage-earners on their board: three members of the *conseil d'administration* are "*ourvriers*" at the Billancourt plant. The main factors in the company's policy have been stabilisation of selling power, maintenance of full employment, expansion of exports and increased investment. Output in 1958 was 28·8 per cent higher than in 1957 and the growth continues.

Renault's annual report contains a very full account of their activities, including the most detailed production statistics over the last 15 years. During that time they have produced 2·3 million vehicles, of which nearly half in the past three years. During 1958 output totalled some 368,000 cars, 41,500 trucks, 21,500 tractors and spare parts expressed in manufacturing man-hours (2·3 million hours in 1958, equivalent to the employment of over 1,000 people during the year). Turnover increased from 216,000 million francs in 1957 to 253,000 million: in 1950 it was only 57,000 million. The company are the largest manufacturers of motor vehicles in France (36·28 per cent of the country's output in 1958) and the sixth largest in the world. Exports totalled over 138,000 road vehicles, accounting for nearly half the French vehicle exports. The United States was by far the leading market, with 61,900 vehicles, followed by Benelux with 14,400 and Germany with 10,400. Employment last year averaged 62,000 in five plants, an increase of 3,000 on 1957.

The company's president, M. Pierre Dreyfus, sounded a warning concerning the future: "the car market," he said, "has acquired several characteristics which it had not exhibited for 25 years." The high price of petrol, the inadequacy of the roads and the weight of taxation threaten the further development of the French market. Any significant decline in sales, warns M. Dreyfus, could mean a most serious recession for the French industry.

Thomas Ward, Scrap and Tools

The earth's curvature over a distance of 1,300 ft is half an inch. The factory planning and installation department of Thomas W. Ward, the Sheffield industrial group, recalled this when, as main mechanical engineering contractors for the new ship hydrodynamics laboratory of the National Physical Laboratory, they were installing the track of the ship tank to a tolerance of five-thousandths of an inch while following the curvature.

The group's annual report and accounts shows profit before taxation up from £2,599,578 last year to £2,775,667 this year. Allowing for reduced taxation and greater transfer from reserves the final increase in the profit is £355,001. In the year under review, the shipbreaking yards were working at only half capacity, not from any lack of ships but because of poor demand for scrap. Open general licences for export of scrap were granted by the Board of Trade in December, 1958, but withdrawn for the heavier grades in March, 1959. Demand has since returned to more normal levels and the chairman, Mr. H. W. Secker, foresees more profitable operation of the shipbreaking works during this year.

The machine tool industry's recession cut down the orders for the subsidiary Frederick Town at the same time as there was less overseas business about. Town's shipments abroad of 65 per cent of their output, achieved for some years, has been cut to about 35 per cent. Although cuts in capital programmes affected Widnes Foundry and Engineering, there were now signs of an improvement in recent months.

Apart from successes in motor cars and heavy electrical equipment, industry was not obtaining the results overseas that it should, observed Mr. Secker. While considering the outlook for most of the group's activities to be reasonably satisfactory, the chairman was not so optimistic in the heavy engineering and machine tool sections.

What's all that Noise?

Acoustical Investigation and Research Organisation Limited is a company whose name explains exactly what it does. In addition it is independent, a non-trading body, and came to life with its research station at Hemel Hempstead, Hertfordshire, looking like something to be established on the moon.

Noise problems, accepted more and more widely as a real problem both of efficiency and health, are coming in for the sort of attention that has done so much for cleaner air. The new organisation—AIRO—is working along three main lines: measurement of acoustic characteristics of machines, materials and electronic transducers; development projects on acoustic problems; and fundamental research in acoustic engineering and electro-acoustics. One of the first tasks of the laboratory will be an investigation of effective sound insulation in lightweight structures—office partitions and ships' bulkheads between passenger cabins.

The laboratory uses high pressure rubber mountings to support the anechoic (echo-free) chamber and the reverberation chamber where all surfaces reflect noise. These two units are protected by a mineral-wool blanket suspended in the cavity between the chambers and the main structure. The ceiling of the reverberation chamber has a precast concrete panel which can be removed along a gantry and lowered to ground level for surfacing with materials which are to be tested for sound transmission properties.

A particular part of AIRO's activities will be directed to the noise characteristics of all types of ventilation plant. It is also intended that all types of mechanical and electrical machines shall be measured for noise characteristics. Spectral analyses of machine noise will be made in the frequency range 20 to 2,000 c/s at frequency intervals of from ½ octave to 1/40 octave. Projects of noise reduction in mechanical devices are also to be tackled.

Electro-acoustic transducers, especially microphones and loudspeakers, will be measured and calibrated by AIRO. The laboratory's standard reference microphones will be calibrated at the National Physical Laboratory from time to time. Absolute reciprocity calibrations will also be carried out at Hemel Hempstead.

The new research laboratory is to maintain a useful liaison both with the authorities at Teddington and with the Building Research Station at Garston, Watford. Both groups have made recommendations which have been embodied in its construction in the design of AIRO's facilities.

Competitor with a Computer

The possibility of reducing the prices of heavy electrical machinery by one-fifth or more within four years is currently envisaged by the General Electric Company of America, through the use of computers. The application of computer techniques to design work has already enabled GE's Transformer Division, Pittsfield, Mass., to reduce the time required to turn out large equipment by 40 per cent. The big saving in time comes in at the design stage: the engineering of a project, which formerly took three to four months, is now handled in two to three days. To the heavy engineering industry of America, which turns out custom built products with a labour content as high as in any other country, where labour rates may be one fifth of their own, the use of computers to replace highly paid design staff and machine tool setters and operators could mean that it will become competitive in world markets. As the consultant John Diebold forecast several years ago, the advent of the computer in the United States is reducing the cost of variety and therefore opening up new markets at home and abroad for American industry.

The GE Transformer Division are using their computer for designing "one-off" transformers ranging from 12 to 250 MVA. The technique involves teaching a large general purpose computer to follow along the decision-making path an engineer uses to design a transformer, and by standardising the components that the computer can select in making up the design, it is possible to turn an entire design job over to the computer. Once the computer can do this, it is only one step further to get it to punch out control tapes for electronically directed machine tools along the production line." Readers of ENGINEERING (21 August 1959, p. 73) will remember an article by M. A. Spurway of Ferranti setting out their design technique in some detail.

The key to success in the use of computers as design and production "tools" is to find reliable ways of replacing, by a series of logical steps based on mathematical calculations, the designer's art which manifested itself in a series of decisions arising, to a large extent intuitively, from experience combined with creative design ability. Computers, say GE, can be used to work out successful designs even quickly and to test their validity, in terms of performance data, without a rough drawing. GE's Engineering Department is operating today with 125 fewer engineer-draughtsmen than it had before, and is still producing the same amount of work. And by 1968, it expects to handle four times the business it now has while adding only a half dozen more engineers.

Pocket Accelerators for High Energies

Runaway electrons are accelerated to relativistic energies in a plasma betatron. Instabilities in the plasma lead to electron losses. When the accelerating field is greatly increased, a new and unexplained phenomenon causes plasma heating.

Cosmic radiation was only an aperitif for the high-energy physicist and present accelerators are not much better than an entrée. The main course of high-energy higher-intensity accelerators is yet to come. These are the words of Mr. J. B. Adams, director of the CERN proton-synchrotron division, spoken at this year's symposium on accelerators at Geneva. The practical limits of building the machines that can provide Mr. Adams' entrée are well known. Present techniques have just about reached their limits of development and the search is now concentrated on finding some new solution. Relativistic plasma, beam stacking, and colliding beam techniques are under development in several countries. Owing to recent developments in plasma research, work on plasma accelerators is now considerably advanced.

Accelerator applications of relativistic plasma were first suggested by G. J. Budker in Russia and N. C. Christofilos in the United States. A relativistic plasma consists of streams of electrons and ions flowing in opposite directions with a relative velocity very close to the speed of light. Budker and Christofilos have independently suggested that the very strong magnetic fields associated with fast moving charged particles might be applied as the guiding field in a high-energy accelerator. As the magnetic field strength would exceed by several orders of magnitude that obtainable with iron or air-cored magnets, an accelerator could be built with a much smaller radius for the same ultimate particle energy. Adams estimates that a 100 GeV proton synchrotron could be built on this principle with a diameter of only 10 ft. For comparison the diameter of the proposed 50 GeV machine in Moscow is 1,640 ft.

Plasma Betatron

A device for producing relativistic plasmas is known as a plasma betatron. The name emphasises the fact that the electrons—or beta particles—undergo the major increase in velocity under the influence of a betatron type accelerating field, although both electrons and protons are present. The usefulness of a relativistic plasma lies in the high circulation current obtainable. In this respect, a helpful analogy may be drawn with the development of the vacuum-tube, where the maximum current is limited by the space charge effect of the electron clouds in the vicinity of the cathode. Adding a small amount of heavy ions in the form of low-density gas neutralises the space charge and the current capacity may be considerably increased. Similarly in an ordinary (or vacuum) betatron, the space charge effects limit the maximum attainable electron current to a value of the order of 10 amperes, but when acceleration takes place in a plasma—that is, an electrically neutral mixture of positive and negative ions—space charge is inoperative and much higher currents of the order of 100 amperes may be possible.

The external appearance of a plasma betatron is rather similar to the various thermonuclear pinch devices which rely on the self-magnetic field of a discharge current to focus or "pinch" the plasma. But the purposes and the principles are quite different: in a thermonuclear device a heavy electrical discharge in a gas-filled tube produces both ionisation, constriction, and heating of the plasma, while establishment of a circulation current is incidental and undesirable. In the betatron, ionisation is produced by some means not directly connected with the acceleration process, and the plasma is accelerated by the application of an alternating "betatron" magnetic field. In the latter device it is the heating of the plasma that is incidental and undesirable. Although the starting points are quite different, the end results are rather similar; the current, either from the discharge of condenser banks or from the accelerated electrons, establishes a pinch effect in the plasma. The differences may be summed up as follows: in a thermonuclear device the drift velocity of the particles is low compared to the thermal velocity; in the betatron the drift velocity is much higher. On this basis, Zeta may be regarded as "cool" compared to a plasma betatron. Expressed on a scale related to the rest-energy of the electron (at 5×10^9 °K), the maximum temperature attained in a thermonuclear device is around 10^{-8}, while in a plasma betatron the temperature is large compared to unity.

Runaway Electrons

Differences between a vacuum betatron and a plasma betatron arise from the presence of the positive ions in the accelerating fields. In a plasma betatron the establishment of two toroidal currents is attempted, which flow in opposite directions and occupy the same space. In order to accelerate the currents, the frictional resistance arising out of collisions of particles travelling in opposite directions must be overcome. The condition when the maximum frictional resistance is overcome is known as "runaway." From this point of view, the current of positive ions may be regarded as stationary, as the ratio of proton to electron mass is in the order of 2×10^3, and only the electron current need be considered.

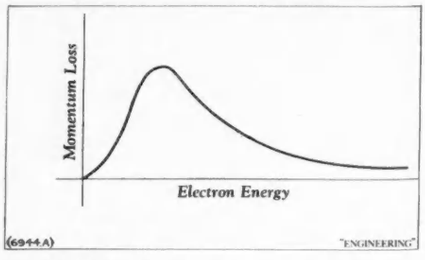


Fig. 1 (above) Variation of dynamic friction losses with particle energy in an accelerated plasma.

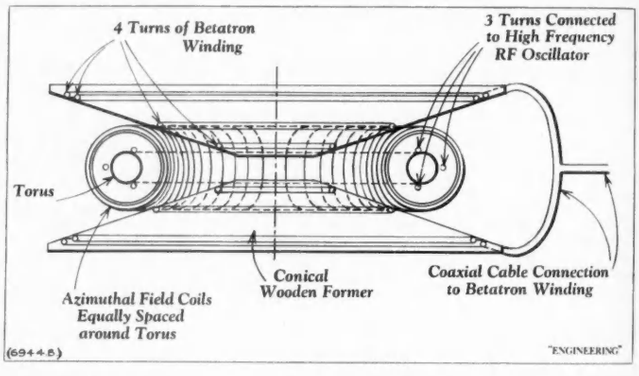

4 Turns of Betatron Winding
3 Turns Connected to High Frequency RF Oscillator
Torus
Conical Wooden Former
Coaxial Cable Connection to Betatron Winding
Azimuthal Field Coils Equally Spaced around Torus
(6944.B)
"ENGINEERING"

Fig. 2 (right) Section of Mark II plasma betatron of the CERN laboratories.

Measurements of the electron-ion Coulomb scattering have been performed; it is found, not surprisingly, that scattering is a function of electron energy.

As a result of the variation in cross-section, the momentum—or friction—loss caused by collisions also varies. Friction losses are plotted against electron energy in Fig. 1, and it is seen that past a maximum, the friction losses fall with increasing energy. One implication of this is that if an accelerating field is applied to *any* plasma, there will always be some electrons in the tail-end of the Maxwellian energy distribution that will run away. It is believed that a portion of the energy losses occurring in Zeta was caused by the runaway effect of electrons possessing high thermal energies at the instant of discharge. The number of electrons which will run away depends on the strength of the accelerating electric field. In order to accelerate all electrons, which is the purpose of the betatron, the field strength must exceed a critical value such that the maximum momentum loss is overcome. The critical field strength E_c is expressed by the formula

$$E_c = 2 \cdot 10^{-12} \frac{n}{T_e} \text{ volts per cm,}$$

where n is the number density and T_e the electron temperature in eV. In practice, the critical field strength is around 0·2 volts per cm.

A second condition for the establishment of a runaway current arises from the requirement that the electric field penetrate into the plasma stream. This condition sets an upper limit on the linear density of the plasma, which must be less than 10^{13}, and implies that acceleration must start in a very weak plasma with gas pressure of the order of 10^{-4} mm Hg. The use of very low gas pressures is also necessary to prevent further ionising collisions with neutral molecules during betatron acceleration. At such a low pressure, pre-ionisation of the gas presents considerable problems. Not only must a substantial number of the molecules present in the gas be ionised, but in order to prevent excessive losses from the accelerating stream, the ionised particles should be confined to the equilibrium radius of the machine. At the plasma betatron laboratory of CERN, where the bulk of development on plasma acceleration was done, a number of pre-ionising methods, such as radio-frequency pulses or Penning gauge, have been tried with varying degrees of success. The most promising development is the use of a circulating pulse of electrons.

Spiral Staircase Ionisation

It is unfortunate that the new pre-ionising process inherited a misnomer from popular parlance: the electron path is no more spiral than the shape of the staircase. Helical staircase ionisation would have been more appropriate. Fig. 3 shows a schematic arrangement of the latest CERN plasma betatron—Mark III—which uses the "spiral staircase" method. A hot cathode projects into the betatron torus from which a short burst of electrons is emitted at the start of the acceleration process. Prior to the emission, a magnetic field is established in the torus. The electron-burst is made to follow a slowly descending helical path under the influence of the field. As the electron path can be made suitably long (or the pitch of the helix suitably small) by the judicious choice of field strength, a very thorough ionisation of the gas can be achieved down to a pressure as low as 2×10^{-5} mm Hg. It is also evident that at the end of pre-ionisation the plasma will be at the equalibrium radius of the betatron. The density of

the resulting plasma can be controlled to a degree by the value of the electron emission from the cathode, which usually has a duration of about 20 microseconds.

Instabilities

Both thermonuclear pinch devices and the betatron suffer from plasma instabilities. Further similarities between the two machines result from attempts to control such instabilities. Damping may be achieved by applying external controlling magnetic fields, or by the device developed for the thermonuclear pinch machine known as a " trapped " field.

If a magnetic field is established in the torus prior to onset of pinching, the development of a plasma envelope " traps " a portion of the field. The resulting " tensions " have been found to exert a damping influence on certain types of instability, in particular the " wriggling " of the discharge.

The situation in the plasma betatron is further complicated by relativistic effects. When a magnetic field is used to guide a beam in a circle there is a definite interrelation between the radial and tangential acceleration of the particles. If a varying betatron-type magnetic field is used for the tangential acceleration, the change in the path-radius of the particle outweighs the change in tangential speed. As a result, the more energetic particles lag in phase with respect to the accelerating field and appear to have a " negative mass." A good solution already developed for similar problems in proton synchrotrons is the application of alternating-gradient focusing, and may become necessary also in plasma accelerators.

Status of Development

So far five plasma betatrons have been built at CERN. Owing to a certain amount of duplication, this only represents three stages of development, mainly in the method used for pre-ionisation of the gas and the strength of the accelerating field. In the Mark I machine, which used a Penning gauge for pre-ionisation, the maximum electric field was only 6·7 volt per cm. Although theory predicted that such a field strength should be sufficient for the production of a runaway current, only conduction current induced by the magnetic field was detected. It was suspected that the runaway current—presumably small—was dissipated by various forms of instability, and hence to make the current apparent, its initial value would have to be substantially increased. The Mark II machine was derived from its predecessor by certain modifications to the betatron field windings. The electric field strength was increased to 18 volt per cm, and in this machine a portion of the runaway current survived the instabilities and was accelerated to the full design energy of 2·2 MeV. Unfortunately, the total runaway current produced in this machine was only about 1 amp, considerably below expectations.

To ensure survival of a larger portion of the runaway current, the Mark III machine was built. Mark III incorporated the spiral-staircase pre-ionisation technique to permit the use of lower-density gas, and certain geometrical advances in conjunction with a field strength approaching 100 volt per cm.

Disappointment or Surprise

To date, only a few experimental runs have been completed and the results are inconclusive. The most surprising observation so far is the total absence of a runaway current. This indicates a discontinuity in the development of the concept: in Mark I and Mark II it was found that increasing the field strength from 6·7 to 18 volt per cm resulted in a definite increase in runaway current. But when the field strength is increased to 100 volt per cm, nothing happens. Such a discontinuity in a relationship usually indicates the emergence of some new phenomenon, and the fact that severe heating of the plasma was observed lends substance to the argument. It is too early to come to conclusions at a time when the Mark III experiments are still in progress. Speculation in the meantime centres on the coulomb-heating effect of the runaway electrons. It is possible that when the field strength is increased by an order of magnitude, the runaway electrons " bunch " rather than travel as individual particles and heat up as a result? The answer is not yet available, but if the theory of coulomb-heating is proved to be valid, it would indicate a convergence of the separate paths followed in thermonuclear and accelerator plasma research.

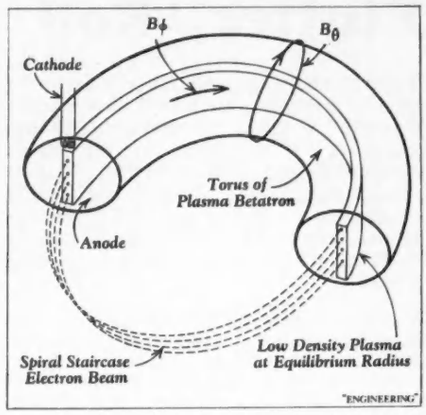


Fig. 3 Plasma betatron, showing the " spiral staircase " method of pre-ionisation.

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Limits of Computer Speed

However fast a computer, someone always wants one even faster. Where the limit to speed lies is a matter of argument. Some see organisational matters within the machine as the chief retarding force, others, more hopeful, the speed of light. Recently the Institution of Electrical Engineers provided an opportunity for these and other points of view to be raised in a discussion of " Future Trends in Memory Stores for High-Speed Digital Computers."

In opening the discussion, Mr. W. Renwick pointed out that physical size was an important limitation to high speeds. For example, in a parallel store made up of discrete storage elements at a linear spacing of 10 bits per cm., there is a delay due to the finite velocity of signal propagation, which amounts to 1 millimicrosecond for 300 bits—without taking into account effects of capacitance and inductance. Most computers have a high-speed store and a high-capacity low-access time store: as computer speeds go up the proportion of high-speed storage will have to be reduced.

In the immediate future higher speeds will be gained by pushing ferrite core methods to the limit. An order of magnitude may be gained over existing systems in this way, reaching an access cycle time of about 0·5 microsecond for 1,000 words.

Much work is being done on evaporated magnetic and superconducting films. Experimental switching times of these low temperature devices show the possibility of a significant reduction in access time. Heat conduction along the output leads is the chief practical problem at present.

Confidence in their development programme to produce computers a thousand times as fast as contemporary ones has recently been expressed by the Radio Corporation of America. According to Dr. J. A. Rajchman, associate director, David Sarnoff Research Centre, Princeton, New Jersey, emphasis is placed on new methods of performing all basic computer functions. One of the systems being studied uses microwave and solid state techniques. Pulses in the 1-10 kMc/s range are used, with a 180° phase change to distinguish the digits. Thus oscillations in one phase represent 1, while oscillations in antiphase at the same frequency represent 0. " At the operating speed achieved experimentally in the laboratory, light travels only 2 ft in the time required for a simple computation such as the adding of two digits," said Dr. Rajchman. So circuit connections are kept short.

A major limitation to the speed of all present storage systems is that reading out information from the store also destroys the information. A significant increase in speed could be gained by the use of non-destructive read-out.

Digital-Computer-Controlled Analogue Computer

Occupations open to a well-qualified digital computer grow in number. A relatively new one is the management of other computers. In "An Automatic Analogue Computer for Missile-Homing Investigations," by J. G. Thomason, the control of an analogue computer by a digital computer is described. The author summarises the project as the installation of an " automatic operator " and an " automatic clerk."

The need for the computer was recognised during theoretical studies of guided missile performance at the Radar Research Establishment, Malvern, Worcs. During this work, it was discovered that an analogue computer running with a 1 : 1 time scale was about 60 times faster than one of the establishment's digital computers, the latter solving the set of equations involved by a modified Runge-Kutta programme. The size of the ratio, coupled with the competition for digital computer time, led to the design of an automatic analogue system. The analogue computer runs and resets its parameters in response to an input programme punched on paper tape; it encodes the results and punches them on output tape. A digital computer reads the output tapes and prints out tabulated reduced data, also operating a graph plotter if programmed to do so.

Conventional 5-hole paper tape is used for the input to the analogue machine. A tape reader feeds a conventional relay " tree " that produces a 24 V pulse on one of 32 terminals which corresponds to the character being read. The thirty-two characters are named as in teleprinter usage—twenty-six letters, one " space," four " format " instructions, and a blank tape signal (not used). Each letter is associated with an electromagnetic device—for example, Ledex wafer-switch actuators, or relays—so that a letter will advance a switch one position or switch a signal in or out by relay contacts. Thus, parameter changes and input signals may be programmed to take place between computations.

Flutter, Roll and Fatigue

Temperature gradients in aircraft wings, caused by high speed flight, promote wing flutter. Changes in aircraft proportions since 1945 have reduced roll stability and may necessitate autostabilisation. Unexpectedly high tailplane stresses occur during spin.

Make your aircraft sufficiently supersonic and the wings get hot. Accelerate to Mach 3 at 20,000 ft, for example, and a temperature gradient of over 130° C can appear. Naturally this is of interest to the structural designer, who begins to wonder how much the wings will bend. A particular wing form is examined from this point of view in " Flutter of an Untapered Wing, Allowing for Thermal Effects," by E. G. Broadbent (CP No. 442, HMSO). As the title discloses, bending need not be the only result: flutter can appear too.

Thermal stresses lower the torsional and bending stiffness of the wing and increase the anticlastic curvature that goes with any bending deformation. The author points out that while the latter effect is stabilising in the static case, it is likely to be destabilising in aerolastic vibration. For the wing form he considers the critical flutter condition given by a Mach number of 3·6.

The wing examined was rectangular and clamped at the root. It was solid steel, having a panel aspect ratio of 1·5 (that is, a net tip-to-tip aspect ratio of 3) and a symmetric biconvex section of 2 per cent thickness chord ratio. Flutter analysis was made for a system of two degrees of freedom: one of wing torsion in which the rate of twist was assumed to fall linearly to zero from root to tip; the other of wing bending in which the spanwise curvature also falls linearly to zero from root to tip. These modes satisfy the tip condition of zero bending moment and zero torque.

Heating effects are assumed to give rise to a parabolic temperature distribution across the wing, calculation being based on a temperature difference of 133° C. Langrange's equations are used, so that elastic coefficients are obtained from strain energy, inertia coefficients from kinetic energy, and aerodynamic coefficients (based in this case on piston theory) are obtained by considering virtual work done in a small displacement. The aerodynamic assumptions are such that the flutter speed would have been infinite with no chord-wise curvature.

The apparent contradiction between the specified root restraint and the specified degrees of freedom does not invalidate the result. It has in fact been shown that the root constraint could be effective to a distance of about a quarter of a span from the root. The net effect of this is to increase the flutter speed to Mach 3·8.

The conclusion that thermal stress can markedly decrease flutter speed at high Mach numbers is a serious one, but for a thick wing the effect would be much less—because of greater intrinsic stiffness, smaller drop in stiffness, and less adverse camber change. Also a wing may be designed to keep thermal stress at a low level. For example, a torsion box could be used instead of a solid section. This would keep the flutter speed high.

IN ROLLS—THE UNEXPECTED

Anyone who thinks that a test pilot's job, apart from when a component fails, has become something of a routine since computers arrived, will be interested to know that the unexpected can still crop up—a new flying effect, for example.

However, computers have again stepped into the breach. They make it possible to solve nonlinear equations of motion and to find out the way any aircraft responds to aileron manoeuvres. A preliminary account of such a study appears in " Preliminary Note on the Effect of Inertia Cross-Coupling on Aircraft Response in Rolling Manoeuvres," by W. J. G. Pinsker (CP No. 435, HMSO). Using GEPUS (a general purpose simulator at RAE Farnborough) to represent a supersonic fighter with 5 degrees of freedom, a systematic series of computations was carried out to discover the response to aileron movements. It turned out that gyroscopic forces couple the pitching and yawing motion, resulting in large peak amplitudes in incidence and sideslip, when inertia in pitch is large. Peak amplitudes usually occur after the end of a rolling manoeuvre.

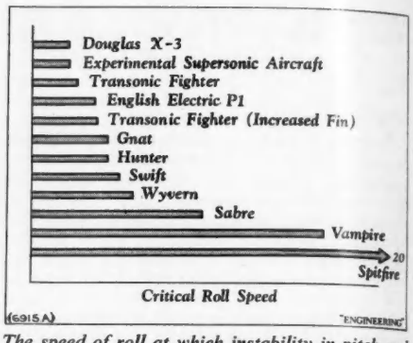
Such effects were not found in typical Second World War fighters. Four main features have combined to lower the critical rate of roll at which the effect is found into the range required in normal aircraft handling—say below 3 radians per second. The features are: increased wing loading, large inertia in pitch (shorter wings, longer fuselage), decreased ratio between inertia in roll and pitch (shorter wings, longer fuselage), and increased operational height (allows faster rolling at lower speeds: critical rate of roll is proportional to airspeed). The comparative values of a critical rolling speed for a number of aircraft are shown in the diagram.

As a result of flight experience, pilots have been advised to refrain from recovery action with rudder and elevator and to bring the ailerons gently back to neutral once rolling instability is experienced. (The term instability is here used loosely to describe the occurrence of large peak values of yaw and pitch during a manoeuvre, though it is not necessarily the result of instability of motion in the strict sense of the word.)

Usually the peak values of pitch and yaw recorded are greater if ailerons are held on longer. In some cases, however, intolerable peaks are reached when rolling through only 90° bank angle and less, and the response hardly deteriorates when the duration of the manoeuvre is increased. In some cases, again, the response is noticeably improved if ailerons are held on longer and the resulting motion depends in a rather unsystematic way on the precise instant at which the manoeuvre is ended. Rapid control movements are generally detrimental.

The calculations carried out show the existence of an autorotational rolling state, which is provoked once an aircraft exceeds a given critical rolling velocity. The practical implications of this phenomenon are not known, but it suggests that even when the ailerons are returned to their central position the aircraft will continue to roll. It too is generated by the effects of inertia coupling, and will occur only if the trimmed incidence of the principal inertia axis is below a certain critical value. For a typical advanced supersonic bomber the critical rate of roll can be as low as 20° per second.

It looks as though it will be difficult to operate the aircraft controls in such a way as to overcome the coupling effects. Pilot control to suppress the pitch and yaw divergence requires very large elevator and rudder movements, which appear unrelated to readily perceptible physical or visual sensations. Autostabilisation has been studied in the report and three techniques are discussed. Pure pitch or combined pitch and yaw damping are relatively efficient. Alternatively, an elevator and rudder control function can be evaluated to counteract the inertia cross-coupling and so almost completely suppress the pitching and yawing motion. But the equipment would not work from an error signal. It would have to follow a derived control law and this would have to be precisely maintained: overcompensation reintroduces the inertia effects with reversed sign. Perfect rolling could be achieved with an autostabiliser operating the rudder and elevator to another derived law, but this too would call for a precise servo mechanism. All methods discussed require very large control movements, which may even exceed the physically available range.



The speed of roll at which instability in pitch and yaw occurs has become steadily less. The diagram compares the critical roll speed for a number of aircraft flying at 240 knots.

Strain gauges showed that buffeting of the Provost tailplane and fin is very severe during spins.

The actual programme of computations was divided into two categories: investigation of individual aircraft designs in cooperation with manufacturers in which nothing alarming was found; and a systematic investigation of the effect of all relevant parameters both with respect to aircraft design and aircraft manoeuvres. The second category enabled the determination of the predominant parameters, so that the number of variables could be reduced to a manageable order. Now a more comprehensive programme of study using the reduced parameters is in progress.

FATIGUE IN THE PROVOST'S TAIL

Strain gauges were attached to the tailplane and fin of a jet Provost trainer. Their output on a carrier wave was recorded during flight.

The most striking result was the severity of the buffeting of both fin and tailplane during spin. It went on throughout the whole period of rotation. Oscillations were rather erratic, in the range 13 to 15 cps, the motion of the tailplane being mainly antisymmetric. Severest oscillation occurred at the end of the spin. The significant point is that at this stage the oscillatory loads are superimposed on the manoeuvre loads associated with recovery from the spin. And as the manoeuvre load in the tailplane acts upwards mainly on one side, it can combine with the buffet loads to produce root bending moments as large as 35 per cent of the ultimate bending moment. Maximum loads of similar severity occur in the fin for a similar reason, but direction of maximum load depends on the direction of turn.

The effects of other manoeuvres are much less severe. For further details see " Fatigue Loadings in Flight: Loads in the Tailplane and Fin of a Jet Provost," by Anne Burns (CP No. 440, HMSO).

On the Shelf

By Frank H. Smith

Librarians are constantly moaning about their inability to get enough room to accommodate all the material they acquire. They point out that their stocks grow yearly but that their shelves stay much the same in length. There is one way in which some of the technical libraries could get rid of a lot of stuff. Many of the journals are from kindred societies and institutions with whom there are interchange arrangements. A large number of these societies are located in London. If these interchangers could get together and agree to allow their members facilities to look up back and current numbers of each others home-produced periodicals, there need by no interchange and the cooperating libraries would save an immense stretch of shelving.

In time the idea might spread to the Stationery Office, which seems to send masses of reference books (at public expense) on subjects which do not concern them to the various Ministry libraries under its wing. Has it ever occurred to anybody to have one central library to serve Food, Aviation, War, Defence, Labour, Works, Education, Agriculture and Fisheries, Treasury and the rest?

The National Central Library have issued their annual report for '58-59. I note that the heaviest international traffic is with West Germany: not only have they borrowed more books from us than any other country but they have lent to us almost the same number—again the highest figure in this class. I suppose there is some significance here. Closeness of interests or bonds of friendship or something. Hungary seems to be the nearest competitor in the outward bound traffic.

One doesn't form a private company every day but when one has to, one probably wonders how to go about it. This is where you buy *Formation of Private Companies*," by D. Barker and A. P. Halberstam. After that you probably consult a solicitor. But the preliminary reading matter will cost 25*s* and it's published by our old friends Sweet and Maxwell.

If you are asked for a book published in India, I'll bet you will have to think twice and then fail to get the answer. Asia Publishing House, of 447 Strand, London, WC2, have a 1959 *Catalogue : Books from India*. There are 23 subject headings and—who knows?—one of them may be *yours*.

A folder can be obtained from the Theatre Americain, avenue de Meisse, Bruxelles, Exposition (it looks a funny address but that's the best I can make of it) describing the publication of the *Book of the Brussels Exhibition*. If you are not too satisfied with that address you can make the first two lines Exposition Universelle et Internationale de Bruxelles 1958, Commissariat General du Gouvernement. Then put the rest—if there's any room on the envelope.

The catalogue cum journal put out by Wallace Heaton (New Bond Street, London, W1) is priced at a shilling but I am not sure whether they actually charge that. Apart from the "lines" it advertises the publication contains authoritative articles on movie, still, black and white and colour photography and all the rest of the mystique of modern shutter manipulation. I know I'm a bit late mentioning this (the current number is 51) but I thought you might like to know. The cover of the September number is an excellent colour example of the beauty to be found in three toadstools amid bracken.

Kingston upon Hull's library's bulletin for October mentions that there are over 2,000 directories in the library there. This number includes a complete set of UK telephone directories, which is a nice gesture by what is, I believe, the only town in the country still to have its own telephone system. It's the cheapest too, isn't it? (Rhetorical question only.)

DEVELOPING THE FRINGES OF THE ARCTIC

The Canadian Northwest: Its Potentialities. Symposium presented to the Royal Society of Canada in 1958. Edited by FRANK H. UNDERHILL. Published for the Society by the *University Press, Toronto;* and *Oxford University Press, London.* (32*s*)

Although 40 per cent of Canada's total area lies in its Northland, beyond the boundaries of the provinces, it is an area very little known even to Canadians. Canada's population is concentrated in what may be described as a "thin red line" stretched along the border adjoining the United States. In very few places does this populated area exceed a depth of 300 miles. This means that the northern half of all the provinces, except the Maritimes, is virtually unoccupied and only partially explored.

Despite the challenge of this vast frontier, possibly because of the crowding along the US border, the average Canadian's preoccupation is with things which happen in his immediate vicinity or to the south of the 49th Parallel. Indeed what is known as "the great Canadian haemorrhage"—the loss of population to the United States—still goes on unabated. This is a great tragedy for Canada and explains, in part, why the northern latitudes of the country are still virtually untouched.

The Royal Society of Canada is very wise in producing this symposium, which will help to acquaint Canadians with their Northland and should also have the effect of attracting enterprising peoples from other parts of the world to develop the great potential which exists.

This symposium is concerned with the northwest part of Canada, the limits of which have been variously described throughout the book; but roughly speaking it is that part of Canada which lies west of the 110th Meridian (the Saskatchewan-Alberta border), and north of the 55th Parallel. This is the third publication in a "*studia varia*" series presented annually by the Royal Society of Canada since 1956.

The 100 pages of this volume are packed with information and include a short introduction by the Abbe d'Eschambault, who gives a thumbnail history of the region since the early days of the Hudson Bay Company. There follows in turn, by experts in their particular field, assessments on five subjects, namely: the engineering problems; the geographical realities; the potential of minerals and fuels; the biological potentialities; and the extent of resources. All these assessments are written with a most realistic approach and do not underestimate the difficulties that stand in the way of the development of the Canadian Northwest; but all the writers obviously have a belief in the future of this vast area.

The particular problems which come out in the symposium are the importance of developing suitable housing for inhabitants of the area, and the solving of problems peculiar to the Arctic area such as permafrost ground conditions, sustained low temperatures, the darkness during the winter months, and so on. Evidence that these problems can be overcome is found in the great number of people now living in the Arctic who are happily settled there and, after becoming used to the tempo of life do not especially wish to "come out" as the old Klondikers put it. This state of mind has been referred to by many writers as "the spell of the Northland" and must be taken into consideration as a point in favour of northern development and settlement.

The last chapter in this symposium is entitled "A prelude to self-government in the Northwest Territories" and the writer points out the inevitability of autonomous government for both the Northwest Territories and the Yukon Territory.

The book contains an excellent bibliography and reference notes. On the inside of the back cover is an envelope which contains a large-scale map of the area and which makes the texts of the various subjects that much more easy to follow.

It must be borne in mind by the reader of this symposium that the situation in this part of the world is constantly changing and the southern border of this untapped region has been gradually pushed northward. As an example: it was only a few years ago that the site of the aluminium smelter and the township of Kitimat, was considered by many Canadians to be in the far North; whereas it is indeed 70 miles south of the 55th Parallel. The same could be said of the city of Prince George. It must also be realised that there is an increased pace in the tempo of development in the northern parts of Alberta, British Columbia and the southern Yukon. As an example of this, the Peace River power project is to start in the spring of 1960 with the building of a dam near Hudson Hope to create the largest man-made lake in the world, which will eventually produce 4,200,000 horsepower of hydroelectric energy.

The recent announcement of the discovery of oil in the northern part of the Yukon, in the Eagle Plain area—which touches the Arctic Circle—will further accelerate development.

Of interest too is the discovery of oil in the Arctic Islands, which are a projection of the Western Canadian sedimentary basin. This discovery and the recent voyage of the Nautilus under the Arctic ice has brought forth the startling fact that oil could be shipped to Western Europe by submarine tankers. The distance from the Arctic Islands to the United Kingdom is only 3,000 miles as compared with 8,000 miles from the Persian Gulf to British ports.

The granting of statehood to Alaska has turned American and Canadian eyes northward. Negotiations have already been started for the building of a rail link between the State of Washington and the new State of Alaska. This will have to be routed through completely new territory, presumably in the northern part of British Columbia and through the Yukon.

The development of Alaska is a practical example of what can be done in the Canadian Northwest, when it is considered that Fairbanks and Anchorage are now skyscraper cities, where the inhabitants live normal lives at a distance of over 1,000 miles north of the southern border of the Canadian Northwest as defined in this symposium.

This book should be a "must" for engineering firms and industrialists who now operate, or intend to expand, their operations into the Canadian Northwest—one of the last great frontiers left in the Commonwealth.

H. F. E. SMITH

DECKED IN ALUMINIUM

An International Review of Aluminium in Modern Architecture, 1958: Companion to *Aluminium in Modern Architecture*. Vols. 1 and 2. Published for Reynolds Metals Company by *Reinhold, New York; Chapman and Hall, London.* (40*s*)

Two years ago the company for which this book has been written published two volumes in hard covers, devoted respectively to aluminium as a material and to buildings in which it had been used. This new publication is described as the first annual supplement. It contains pictures and notes about 26 more buildings in Europe and America, some interviews with European and American designers, and a short article on anodising. There are 110 pages, in aluminium-backed paper covers.

This sort of advertising presents its problems. There is an understandable desire to include as many buildings as possible, to convey their general character, and to picture the uses of a particular material. Compromise becomes neces-

Continued on next page

sary and this publication suffers from it, for the actual uses of aluminium are often difficult to identify or assess in the examples. Jacobsen's School at Vangede, in Denmark, is an example, for none of the pictures show the aluminium. It might be more useful to handle such material in future by discussing individual types of product or element, for example, wall-cladding, roofs, windows, doors and structural frames.

It is perhaps too much to expect advertising to be self-critical about a product, but to English readers, at least, this volume may leave an uneasy impression. Notes of caution about corrosion and maintenance of appearance are not sounded, and errors or optimism in the text somewhat undermine confidence. Examples: the Jespersen building in Copenhagen does not have sealed windows, but only in the facade shown; sound attenuation of 50 db is highly improbable by special sprays on sheet metal.

Maintenance of appearance is probably the vital point in the British climate for we have had disappointments, and on this score the doubts are not dispelled. The article on anodising is the best item in the book, but durability of it is again left too much to the imagination.

W. A. ALLEN

REPEALING THE SECOND LAW?

Foundations of Thermodynamics with Antitheses and Disputation. By SVEN SVANTESSON. *Almqvist and Wiksell, 26 Gamla Brogatan, Stockholm C, Sweden.* (*12 Sw. kr.*)

This little book is the only modern work on the subject which seriously challenges the current acceptance of the Second Law of Thermodynamics and its application in chemical dynamics. The author is unknown to the reviewer but it is made obvious in the book that he has been in communication with several leading European authorities for some time and that generally they disagree with him, though they are prepared to give way on some points. The style and presentation of the book are reminiscent of older works but considering the author is Swedish his grasp of the English language is remarkable. This book will not be appreciated by those who are not familiar with the fundamentals of thermodynamics and have not had to grapple with the fundamental concepts of the subject. It is unsuitable for the casual user in applied branches of thermodynamics.

The reasons for writing such a book are best taken from the author's preface: "The author belonged to the early enthusiasts. Thus in 1924 he 'went back to school' and submitted to an intense thermodynamic discipline at its then very stronghold, the University of California. Instead of the firm rock of unambiguity and lucid exposition looked forward to, he found thermodynamic theory a dismal swamp of unsound metaphysics, forced arbitration and expedient compromise. These findings together with an accredited mastership of the discipline, such as it was, precipitated the conception of a difficult task. Its challenge was accepted, here it is finally discharged." The reviewer sympathises with the author's disappointment with his early studies as he himself was subjected to a post-graduate course in thermodynamics during which time was allowed for cogitating the more fundamental concepts and reading "the classics." He agrees with the author that some of the early work contained suspect arguments and also many mathematically intolerable concepts such as reversibility and ideal engines, but considers that this classical treatment is largely superseded by the work of Caratheodory.

In the book the author's own treatment is given separately from that of the "Old Masters," Clausius, Planck, Carnot and Kelvin, to mention only a few, but he appears to expend more energy in pointing out apparent fallacies in their arguments than he does in making sure his own are clear. It is most surprising that the work of Caratheodory (about 1920) is not mentioned, though some of the mathematical treatment is vaguely similar. The book is a brave attempt to break down long held "beliefs" or "faiths" regarding the Second Law and chemical dynamics. It resulted from the author's deliberations over the last 20 years and should trigger off some reaction which can only be of benefit to the subject. It is asserted that the statement

$$dq = T\,ds \text{ (where } s \text{ is a function of state to be called entropy)}$$

does not hold generally and that a *perpetuum mobile* of the second kind is theoretically possible. The challenge has been issued and it will take considerable effort to prove or disprove its validity.

The criticism of the work rests on two points which are related: (*a*) no effort is made to consolidate by a thorough discussion of, and an attempt to define "heat" and "temperature"; (*b*) the work of Caratheodory is not mentioned. It is worthwhile here to bring out the main points in Caratheodory's treatment of the Second Law of Thermodynamics since his works were written in German and took some time to filter through to the English speaking world. In the classical treatment which finally was accepted early in this century many conceptual devices had to be resorted to and the subject was fraught with untidy logic. Caratheodory showed that by suitable basic arguments heat and temperature could be defined in terms of classical mechanical concepts. His basic axiom for the Second Law is "Arbitrarily close to any prescribed initial state there exist states which cannot be reached from the initial state as a result of adiabatic processes." From this much more general statement of experience the argument leading to the statement

$$dq = T\,ds$$

is developed mathematically using the theory of Pfaffian differential equations.

The review has dealt entirely with the Second Law analysis which forms little more than half the book but it is felt that this aspect is the more fundamental. The application of thermodynamic theory to chemical dynamics through the Helmholtz and Gibbs functions is of lesser importance.

WILLIAM DRUMMOND

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Heavy Engineering. DOMINION ENGINEERING WORKS LTD., P.O. Box 220, Montreal. Forty page booklet describes the products of the firm which range from propellers through turbines to presses and diesel engines.

Ships and Engines. BURMEISTER AND WAIN'S MASKIN-OG SKIBSBYGGERI, 4 Strandgade, Copenhagen, Denmark. Engines, ships and steelworks of the company are magnificently presented and illustrated in colour in a 90-page book.

"What We Make." AVELING BARFORD GROUP, Grantham. Road rollers, dumpers, road machinery, and agricultural plant are included. Publication No. 1771.

Prototypes. ENFIELD TOOL MANUFACTURING CO., LTD., Alma Road, Ponders End, Middlesex. Precision prototype and production work, tools and dies. Leaflet.

Construction

Wallplugs. PHILPLUG LTD., Chase Road, London, NW10. Adapta wall plugs for fixing nails or screws in masonry. Two sizes only for all screw sizes. Also Tilefix adhesive. Leaflet.

Air in Concrete. SOILTEST INC., 4711 West North Avenue, Chicago 39, Ill., USA. Precision meter for determining the amount of air entrained in concrete mixes. Capacity ¼ cu. ft, can also be used for unit weight test. Descriptive folder.

Timber Buildings. J. E. LESSER AND SONS LTD., Green Lane, Hounslow, Middlesex. The Middlesex range of sectional timber buildings from 8 ft by 6 ft to 60 ft by 30 ft. Complete with doors, floors and roof. Leaflet gives full details.

Mobile Buildings. SWIFTPLAN LTD., 39 Victoria Street, London, SW1. Mobile buildings for industrial purposes; can be quickly erected and dismantled for transfer to another site. Built on a 24 ft by 8 ft grid with panels 3 ft and 5 ft wide. Booklet.

NEW BOOKS

Third Congress of the Fédération Internationale de la Précontrainte. Berlin 1958, Volume 1, Papers; Volume 2, Discussion. Editor: RALPH P. ANDREW. *Cement and Concrete Association.* (£13)

It is regretted that the price of this was given incorrectly in our original note published in ENGINEERING, 30 October, page 418. The price should be £13 for the two volumes, as indicated above.

Transistor Circuits. By K. W. CATTERMOLE. *Heywood and Company Limited.* (70*s*)

Transistors being "the thing" it is inevitable that there should be a glut of books covering their mysteries. The author of this one is with Standard Telecommunications and he takes the reader gently by the hand and provides an ample bibliography to supplement the text.

A Diderot Pictorial Encyclopedia of Trades and Industry, 2 volumes. By DENIS DIDEROT. *Dover Publications, New York; Constable, London.* (148*s*)

A new edition, the first in 150 years, of Diderot's collection of plates engraved to illustrate the the *Encyclopédie* in 1763. The reproduction is beautiful and the introduction is scholarly and interesting. In the two volumes there are 485 plates, most of them requiring the full page size 12 in by 9 in.

New Developments in Training. Edited by FRANK A. HELLER. *Polytechnic Management Association.* (5*s*)

Sub-titled "Five studies in the Efficient Communication of Skills" they are: "A Biologist's Contribution to Learning" by Professor Young; "New Methods of Training in Manual Skills," by W. D. Seymour; "Recent Survey Findings in the UK and other European Countries," by Winifred Raphael; "Training for Executive Skills, by the editor; and "The Integration of Training, Organisation and Policy," by S. D. M. King. Only 80 pages long, they were originally lectures to directors and senior executives.

The Reviewers

Lieut.-Colonel H. F. E. Smith, E.D., is industrial and trade secretary in London for the Government of the Province of British Columbia. From Vancouver, he has now been resident in Britain for 10 years and is responsible for industrial and trade matters in the United Kingdom and Western Europe. He has long been interested in the territories of the Canadian Northwest.

Mr. W. A. Allen is chief architect at the Building Research Station. He was born in Canada, where he obtained the degree of B.Arch., and came to England in 1936. After practising architecture in this country, he joined the Building Research Station shortly before the war. He is a fellow of the Royal Institute of British Architects and a member of the Illuminating Engineering Society and the Acoustics Group of the Physical Society.

Mr. William Drummond is engineer in charge of reactor physics and performance in the atomic energy department of Babcock and Wilcox Limited. He took an external B.Sc. (Eng.) at London University and obtained first class honours, and in 1953 attended a post-graduate course in thermodynamics at the University of Glasgow. He is an associate member of the Institution of Mechanical Engineers.

Penetrants for Non-Destructive Testing

By Robert Schnurmann,

Esso Research, Abingdon, Berks

The need for simple, quick and cheap non-destructive flaw detection methods has become widely recognised throughout industry. The last ten years have witnessed a considerable development of novel penetrant methods which have been added to the armoury of non-destructive examination.

Penetrants for flaw detection are spectacular in their performance and rank among the simplest and most economical methods to operate. Yet, such methods of inspection are still not much written and talked about and their inherent advantages are certainly not so widely used as they might be. As with most inspection methods there is no single, entirely foolproof procedure which can cope with every type of inspection problem. However, the benefits to be derived greatly outnumber the drawbacks if the supervising personnel of the inspection department is fully aware of the limitations of the various methods and of the hazards to be guarded against in their operation.

There are two classes of penetrants: " fluorescent inks," and dye penetrants. The fluorescent ink methods can be further divided into three groups:

(1) The fluorescent dry deposit method.
(2) The wet solution method.
(3) A fluorescent adaptation of the chalk adhesion method.

FLUORESCENT INKS

(1) *The Fluorescent Dry Deposit Method.*—This very simple and rapid method employs a special fluorescing material which is dissolved in a volatile liquid. The solvent quenches the fluorescence of the powder which is dissolved in it, but on applying this solution to a solid surface it dries very quickly and leaves behind a deposit of bright green fluorescence. The human eye is very sensitive to green and usually a deposit in a crack or porous area gives rise to an intensity of fluorescence which outshines the lesser fluorescence of its surroundings.

Sometimes, however, to avoid confusion with tide marks or to bring up more clearly details of the outline of a crack, it may be desirable and even necessary to remove the background fluorescence by means of a suitable solvent. The additional operation of background removal is not required where a crack or porosity extends through the thickness of a material (as very often happens in welding operations) because in this case the fluorescent ink can be applied to *one* face while the fluorescing indication is observed on the *opposite* face (Fig. 1).

The small amount of deposited material presents no difficulty with regard to the further utilisation of the test pieces because the residual dry deposit can easily be removed. This can be achieved either with a solvent or simply by raising the temperature of the examined component for a short time to about 60° C so as to volatilise the slight deposit.

(2) *The Wet Solution Method.*—This is used with advantage for the location of very small defects. It depends on the impregnation of the test piece with a strong solution of a fluorescent material. The impregnated surface is then cleaned with a detergent and finally washed with water and dried. After a waiting period, some of the solution which has penetrated into defects weeps back and forms a thin layer of comparatively large surface area from which some of the solvent volatilises so that a supersaturated skin is formed. This supersaturated skin fluoresces brightly and gives an enlarged outline of very small defects (Fig. 2).

(3) *The Fluorescent Adaptation of the Chalk Adhesion Method.*—In this method the test piece is impregnated with a viscous fluorescent liquid and then carefully cleaned by washing with a detergent solution and vigorous washing with water. After drying a non-fluorescent powder is dusted on the surface. When the powder is blown off shortly afterwards, ridges of this powder adhere to those parts of the surface which have defects and which have therefore retained small amounts of the fluorescent liquid. The white ridges can be seen under ordinary shop-lighting conditions, but the flaw indications become strikingly apparent by their brilliant fluorescence in filtered near-ultraviolet light known as " black light " (Fig. 3).

DYE PENETRANTS

When dye penetrants are used, the good contrast is achieved by the indications of a bright dye solution—usually red—on a white background, instead of by fluorescence as with the methods described above. The technique of application is somewhat similar to that used in the fluorescent adaptation of the chalk adhesion method. The test piece is soaked for several minutes in the dye solution and is then washed off with either kerosine or water according to the nature of the dye solution. The dried surface is then painted or sprayed with a suspension of a white powder in a volatile carrier. The thin coating thus produced dries very quickly and by a blotting action on the dye solution which has been imbibed by cracks or porous areas gives indications of their presence as a coloured stain on a white background (Fig. 4).

Dye penetrants can also be used to produce a permanent record of flaw indications. To this end a transparent plastic coating is applied to the cleaned surface of the impregnated test piece (Fig. 5). The coating can then be peeled off and retained as a record.

LIMITATIONS OF PENETRANT METHODS

For the successful application of penetrants the test pieces must be clean. If cracks have been filled up with oil, grease or mechanical debris, penetrants will not be able to enter. Moreover, the fluorescence of some fluorescent inks is easily quenched by oil or grease. Traces of indicating materials may be difficult to remove from rough surfaces, such as the weal of a weld, where they can be mistaken for cracks in the finished components. However, with some experience on the part of the inspection personnel this should not lead to any serious difficulties. In any event, the flaw detection test can readily be applied again with a clear indication of the presence of any real flaw as a spurious indication very seldom recurs in the same place.

Some of the solvents which are used in penetrant formulations are highly inflammable materials and some of the cleaning fluids are either inflammable or toxic. Fire and toxic hazards must therefore be guarded against by adequate ventilation or other precautions as is customarily done when handling petrol or trichlorethylene, for example.

There are many industries which can derive considerable and material benefit from non-destructive flaw detection, particularly by the selection of an inspection routine which is simple and cheap such as fluorescent and dye penetrant methods. Despite some slight inconveniences and limitations, these methods can provide a very satisfactory means of rejecting flawed components. Besides contributing to economy in manufacture, they also help to ensure safety in transportation and reliability in all forms of engineering.

Fig. 1. Porosity in casting shown in white where fluorescent ink has penetrated.

Fig. 2. Minute cracks in leading edge of turbine blade, wet solution method.

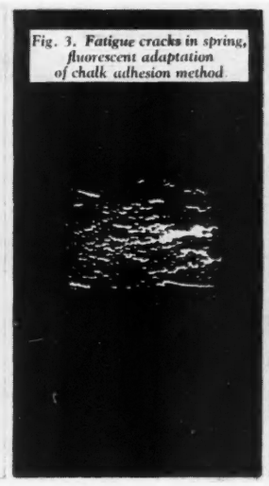


Fig. 3. Fatigue cracks in spring, fluorescent adaptation of chalk adhesion method.

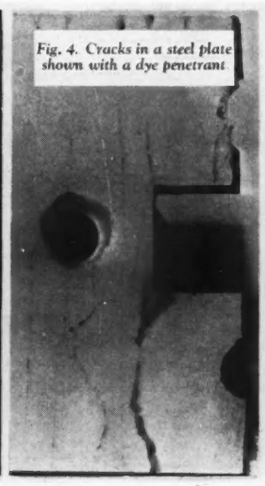
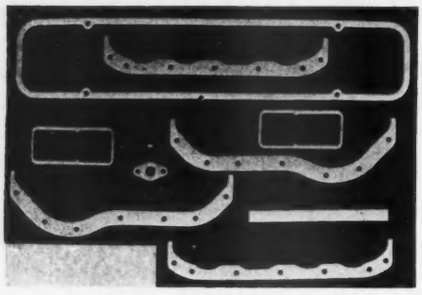


Fig. 4. Cracks in a steel plate shown with a dye penetrant.

Fig. 5. Plastic film coating acts as developer for dye penetrant indication.

Gasket can be Reused

Here is a gasket material which does not mind fatigues. It is a blend of cork with nitrile rubber and is made by British Technical Cork Products of Reading. Properties are inherited from the rubber content, which therefore include resistance to high temperatures—up to 300° F—and appreciable resistance to mineral oil detergent and viscosity stabilised oils, ester-based lubricating oils, petroleum fuels, aqueous coolants and antifreeze solutions. British Geon, incidentally, supply the Hycar nitrile rubber.



Nitrile rubber is combined with cork in a new gasketing which can be reused.

This gasketing is not the first to incorporate an elastomeric binder with cork, but is the first to incorporate nitrile. Ageing is better under all conditions than with cork, and resilience or recovery is that of the rubber—without the uncontrollable side flow usually associated with natural rubber.

The material is said to have " excellent fatigue resistance," and can thus be used for applications involving frequent opening and resealing. Moreover, it resists fungal attack and is dimensionally stable. Four grades are available in sheet form from 0·031 in thickness upwards.

Ten Minute Primer

It was originally formulated as a weathering primer capable of withstanding outdoor conditions for several months without breaking down. Those who know say " it fulfils all expectations." Here, then, is Polyprimer, a general-purpose grey primer that will dry for handling in 10 minutes, may be sprayed, brushed or dipped on most metals and even hardboard and will act as an anti-corrosion primer for out-of-doors weathering. It is announced by Arthur Holden and Sons of Birmingham.

Polyprimer will subsequently accept as a second coat within an hour, air drying industrial finishes, synthetic stoving enamels, stoving hammer finishes, shrivel enamels, cellulose lacquers and even decorative paints. Moreover it will take epoxy-based, heat resisting stoving enamels.

2-(-2-Chloroethoxy) -5-Ethyl-5-Methyl-20xo 1,3,2, Dioxaphosphorinane

Not all petrol fuel additives are blessed with short names like tetraethyl lead or ICA. It is comforting, however, that the one in the title is commonly known as 2CP.

Together with 4BP, this additive has just been announced by Union Carbide International Company, the branch in London being in Mount Street, W1. They both contain phosphorus—hence the " P." " B " in 4BP comes from butyl, and " C " in 2CP comes from chlorine, which is hidden somewhere in the long molecular chain shown in the title.

4BP is recommended as a pre-ignition suppressor and sparkplug antifouling additive, and 2CP has the added role of lead scavenging agent. Neither affects the octane rating of fuels.

While firms are busy thinking up more and more complex molecules to keep the sparkgaps sparking in cars, there is news from America of the properties of paraffins as jet fuels. Texaco have shown that paraffins give more lifting power with less smoke than kerosine. This results from the fact that paraffin fuel burns with a less luminous flame, so that mixtures can be burned at higher temperatures while keeping the heat radiated to interior walls down to the same safety level.

To measure this critical radiant property, Texaco have developed a new rating for fuels—called the Luminometer Number—so if paraffins catch on, it seems likely that a race for the fuel with best LN will come, just as did the race for the highest octane number for automobile fuels.

There will probably even be special additives made to improve it.

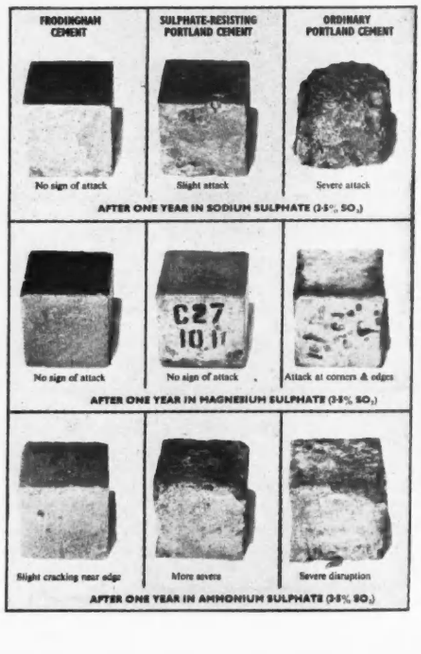
Slag Cement Resists Sulphates

Frodingham to most people spells iron and steel, and to the man in industry such steelworks imply slag—a material which is produced in vast quantities and for which it is very difficult to find a market. It is interesting that the same name Frodingham has now been given to a cement company whose product is a super-sulphated cement, made from just that " waste " material.

About four years ago, tests began to find whether the cement made from Appleby-Frodingham Steel Company's slag was comparable in strength with the continental product. The answer —it is, and it further has better storage properties and is consistent in performance. Thus the new cement company went into commercial operation early this year, their product being distributed mainly by Lafarge Aluminous Cement Company of 73 Brook Street, London, W1.

Outstanding characteristics of the cement are its resistance to many agents which can attack ordinary Portland cement, including sulphates, seawater, oils and fats and dilute acids. The illustration puts this claim on a firmer footing. Heat of hydration is low and suits it for massive structures in hot conditions; its strength is at least that of Portland cement, and it has a pleasing creamy-white colour.

The effect of poor concrete making techniques are more marked with sulphate than Portland cements. Mixes should not be leaner than 1 : 2 : 4 or 1 : 3, physical mixing must be thorough, and concrete must be kept wet for a minimum of three days after placing.


FRODINGHAM CEMENT
SULPHATE-RESISTING PORTLAND CEMENT
ORDINARY PORTLAND CEMENT
No sign of attack
Slight attack
Severe attack
AFTER ONE YEAR IN SODIUM SULPHATE (3·5% SO3)
No sign of attack
No sign of attack
Attack at corners & edges
AFTER ONE YEAR IN MAGNESIUM SULPHATE (3·5% SO3)
Slight cracking near edge
More severe
Severe disruption
AFTER ONE YEAR IN AMMONIUM SULPHATE (3·5% SO3)

Cracking Under Stress?

Hydrogen in steel is serious—it causes embrittlement. The big question is " why," and this is one which is commanding many men's attention in metallurgical laboratories throughout the world.

In Argonne National Laboratory, researchers have been using neutron diffraction (using a stream of neutrons instead of a beam of X-rays) to fix the positions of hydrogen atoms in a crystal lattice. They have successfully positioned other light atoms as well, including carbon, nitrogen and oxygen—and these, it will be recalled, rest in between the larger metal atoms such as iron, in what are called interstitial sites.

The controversy on brittle fracture, which caused, incidentally, great damage in liberty ships, centres around the relative importance of residual stresses left over from welding, hydrogen, pores, microcracks and fissures.

At Argonne the research group ascribes embrittlement to the directional nature of " bonds " which they have shown to exist between interstitial hydrogen and large parent atoms. These bonds, moreover, imply attraction; the forces involved cause distortion of the metal lattice, and it is the combination of the two which gives embrittlement.

Low Dewpoint Desiccant

" Unlike other solid desiccants at present on the market Mobil Sorbead R is spherical in shape and light brown in colour." What difference the latter property makes is difficult to assess—some may like brown, but certainly the shape is important in that it allows high gas flow with little resistance. Sorbead R is one of two products now launched by Mobil Oil Company of Westminster, London, SW1; the other is Sorbead W—another desiccant, but one which will stand up to liquid water without bursting of the aluminium silicate spheres.

The dewpoint attainable with Sorbead R is " generally below − 55° C " which is good, and this is combined with good absorption capacity This absorbtion property derives partly from the specific area which is 650 sq. metres per gm. Aluminium desiccants can be regenerated, and this is done easily by heating to above 100° C but not greater than 250° C, for the Sorbeads.

Suggested applications include dynamic drying such as for wind tunnels and oxygen separation plants; predrying refrigerants such as Freon; and other general uses such as antirusting, and drying of propane, butane, and general chemicals.

New " Marking-off " is a Mist

A result of collaboration between Brent Chemical Products and Rolls-Royce is a new " marking-off " ink known as Ardrox 381, made by the chemical firm at Ardrossan, Ayrshire. This has two unique features which distinguish it from the old slap-it-on water-soluble compounds. First, it is supplied in the form of self-spraying aerosol dispensers which means that a thin, even coating is obtained over the entire surface (of components to be marked). Second, after marking-off has been completed and it is desired to remove the Ardrox, a quick dip in a trichlorethylene degreasing bath will suffice. The avoidance of undue surface scratching and of contact with water should well repay the extra expense of the container, especially when working with finely finished steel components.

Practical Advantages of New Pirelli Tyre

Designers have for years dreamt of a tyre with a separate and replaceable tread. Pirelli Limited have realised this dream with their BS3 tyre, soon to be in production here.

The tread and sidewalls of a normal tyre are applied as a single extrusion to the carcase while the tyre is being built, and are bonded to the structure during curing. When the tread is worn out, the entire tyre must have a second curing process if it is to be remoulded.

The BS3 tyre (Fig. 1), made by Pirelli Limited, Burton on Trent, consists of an inflatable casing or carcase (1) on which are mounted three peripheral tread bands (2) reinforced by steel cords (3). Ridges (4) and shoulders (6) round the crown of this casing locate the bands parallel with one another across the crown of the casing. The bands are slightly smaller in diameter than the casing itself so that, when the casing is inflated, pressure is exerted all round the casing, and the bands cannot be displaced.

The bands can, however, be removed without special tools or equipment when the tread pattern has worn smooth. The casing is deflated and the tread bands eased off. The casing remains in perfect condition even after the tough tread bands are worn smooth, so that after the first set of tread bands has been discarded, a new set can be fitted, and the tyre kept in service.

In the event of a puncture of the inner tube (7) the tread bands will not be detached until a fair amount of deflation has occurred. Even then, the partially deflated casing can travel safely some distance without the bands. Uneven wear of the tread, perhaps as the result of some misalignment or incorrect inflation, need not cause premature failure of the tyre, as with conventional tyres. This is because the bands can be changed around laterally, or from wheel to wheel, to even out wear. If necessary, only part of the tread, that is, a single tread band, need be replaced to ensure that fully efficient treads are maintained on the tyres. With the BS3 tyre, worn tread bands can be replaced cheaply and there is no need to buy a new cover. Further, in the event of accidental damage to the casing, such as might occur by violent contact with a kerb, the casing alone can be replaced, and the original tread bands retained.

The three tread bands are built and vulcanised by a special process. They are made of rubber, with steel cords laid longitudinally to form a virtually inextensible belt. There is no possibility of the belt stretching or fracturing, or in any way failing to exert the pressure necessary to maintain complete adhesion to the casing. The safety factor is thus high. Because the tread bands are manufactured to standards of accuracy not normally required in conventional tyres, the dynamic balance is good. Each tread band is produced by a method which guarantees absolute dimensional accuracy and perfect centring. Fig. 2 shows the standard tread.

The BS3 tyre makes a positive contribution to road safety. This is because of its good road-holding qualities and because there is no need to keep on using bald tyres. In fact, if the tread bands are replaced as soon as the pattern begins to disappear, the casing can be employed, with successive tread bands, for mileages not normally obtained with standard car tyres. The BS3 casing, like the casing of every good quality tyre, will outlast two treads. But the cost of a set of BS3 tread bands is far less than the cost of a new normal tyre, or of a new BS3 tyre complete with tread bands.

Because the whole concept of the tyre revolves round the principle of tread bands that can readily be replaced, the tread pattern can be varied to suit changing road conditions. For normal motoring, on roads wet or dry, the standard tread pattern provides excellent traction. For motoring under winter conditions of snow or mud, a special tread pattern is available. This consists of large solid blocks of rubber which penetrate the soft top surface and grip the hard surface of the road beneath. This is already possible, of course, with certain dual purpose tyres, but in the case of the BS3 tyre the motorist does not have to buy special winter tyres. He merely removes the standard tread bands and slides on the winter bands.

An interesting feature of the tyres is the way they can be used on icebound roads. Gaps (see (5) in Fig. 1) are arranged periodically in the ridges (4) on the casing to take steel studs with a tungsten carbide tip (Fig. 4). These studs have a flat base plate which is inserted between the inner edges of the outer winter pattern tread bands, and the outer edges of the central band (Fig. 3). They protrude just far enough beyond the face of the tread to provide the necessary traction. They are silent in operation, comfortable in use, and keep the car on its chosen path. Tests carried out on an ice rink revealed that it is possible to apply full pressure on the brake pedal at 25 m.p.h., and halt the car in a straight line in about 40 ft.

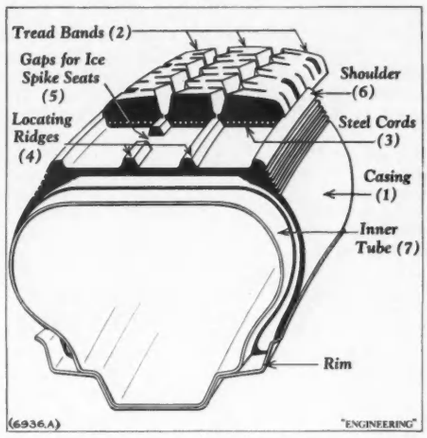


Fig. 1 The Pirelli BS3 consists of an inflatable casing on which there are three tread bands.

Fig. 2 The bands are slightly smaller in diameter than the casing so that when the casing is inflated the pressure exerted will prevent displacement.

Fig. 3 For winter motoring there are special pattern treads to which steel studs can be added.

Fig. 4 (left) One of the tungsten carbide tipped studs.

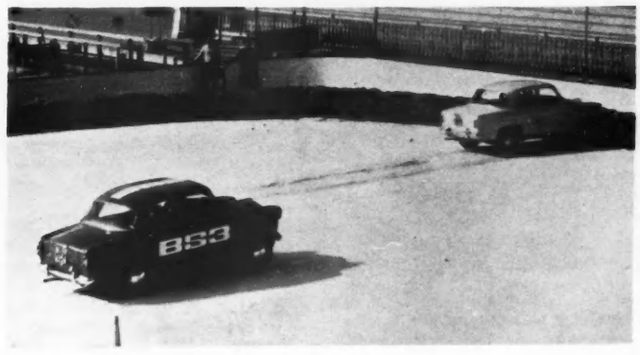


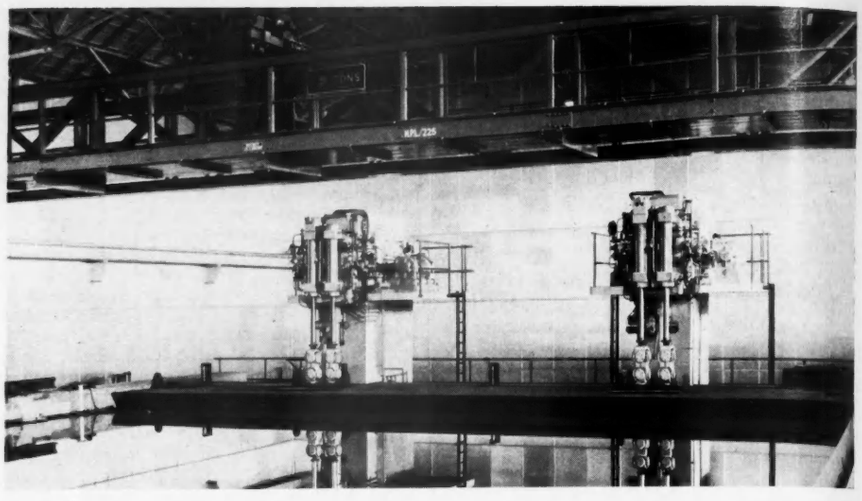
Fig. 5 (right) The BS3 car pulls up when braked.

XUM

Waves Made to Order in this Tank

The wavemaker installed at one end of the new towing tank at the Ship Hydrodynamics Laboratory, Feltham, Middlesex, is capable of generating a uniform train of waves down the full length of the 1,300 ft tank. It takes the form of a wedge shaped plunger spanning the tank, about 48 ft long, 17 ft high and 7 ft wide at the top, tapering almost to a point at the bottom, which is moved up and down to displace the water. It is planned to make waves up to 2 ft high (peak to trough) and up to 40 ft long (peak to peak), with an infinite variety of combinations within these limits.

The plunger is a steel fabrication of some 20 tons. The front face is curved to follow a theoretically ideal contour, and is true to within $\frac{1}{8}$ in over the whole frontal area, quite an achievement for a component of this size. All internal and external steel surfaces are treated to resist corrosion. The frequency of the wave generated depends on the rate at which the plunger is moved, and the wave height is governed by the amplitude of the movement. Control of these motions, which has to be most precise, involves the movement of a large mass with an unprecedented degree of positional accuracy, a very difficult control problem indeed.



General view of the wavemaker equipment at one end of the 1,300 ft tank of the Ship Hydrodynamics Laboratory at Feltham. It shows the electro-hydraulic apparatus for generating accurate waves.

How it is controlled

A system was developed whereby the plunger is moved up and down by hydraulic cylinders and automatically controlled by an electronic hydraulic servo mechanism. This, in effect, continuously monitors the actual position of the plunger relative to the correct position according to the control setting, and applies a correction if there is any error. The hydraulic equipment for moving the plunger is built on two concrete plinths at one end of the tank. The electronic control gear is mounted beneath the hydraulic equipment against the tank wall, and is accessible by a staircase. The hydraulic system was designed and constructed by Keelavite Hydraulics Limited, Allesley, Coventry, and the electronic control system subcontracted to Associated Electrical Industries Limited, Electronic Apparatus Division, Leicester.

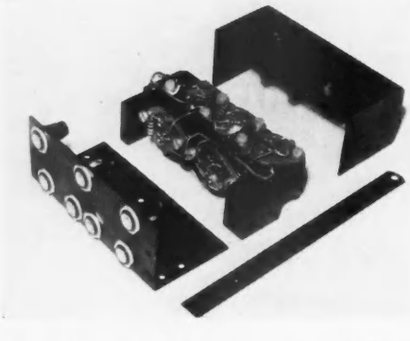
The complete electronic hydraulic system is an outstanding example of a servo control mechanism. The control of this large mass moving at a wide range of speeds, through widely varying distances with such accuracy, is a task almost without parallel. Control of the 20 ton, 48 ft wide plunger, is restricted to very fine limits in both speed and distance. The maximum angular tilt allowed upon the wedge is 4 ft, beyond which the system cuts out, control of the wedge being fully automatic. The required wave frequency and amplitude are set on dials on the control desk and the system started. Operation thereafter is completely automatic, the system cutting off in an emergency.

Control desk for the wavemaker is shown here.

Wax model of ship being cut ready for testing.

Although the dead weight of the wedge is 20 tons, it is in fact a huge tank, and so is buoyant. To move it in the water is not so much a problem of overcoming the weight as being able to overcome the buoyancy. It was at one stage proposed to ballast the plunger with water, but this would have added to its mass and made the control problem even more difficult. Eventually it was decided to use two air cylinders as springs to give the ballast.

High Speed Sequential Switch



Exploded view showing the distribution of the nine transistors and also wiring details of the switch.

Microcell Electronics, a division of Microcell Limited, 9 Kingsway, London, WC2, have been working with the Ministry of Supply on the problem of hazard-free high-speed sequential unlatching of electro-mechanical locks. Electrical reasons prohibit the unlatching of the locks at the same time, and the requirement was thus for a high-speed sequential switch that would unlatch one at a time, the time interval between unlatching being 10 m. secs. Severe restrictions were placed on the unit. The physical size is limited, yet it must not be a "throw away" device, but one capable of undergoing normal electronic test routines and repair if damaged.

A fully-transistorised electronic switch proved the answer to the problem. This switch incorporates a number of sequential stages, each stage switching a current pulse of 5 amp to the electro-mechanical locks. The design ensures that no stage operates before the preceding one has completed its functions. The switch has the ability to wait at a sticking lock for a limited time. Special safety devices then operate, to allow the sequence to continue if the lock refuses to unlatch. The electronic switch scores over a similar electro-mechanical device, because there are no moving parts to jam or wear. Greater electrical efficiency; freedom from vibrational effects; long (almost unlimited) expectation of life; and simple servicing techniques, are other factors commending it.

The high currents required to operate the locks demanded the use of power transistors (germanium types were selected), making it difficult to pack the unit into the small space allowable. The unit weighs 14 oz and is 4 in long by $1\frac{1}{2}$ in high by $2\frac{1}{2}$ in wide. It uses nine transistors, 13 diodes, seven cartridge fuses and 11 other components. The whole unit is fully demountable for servicing and repair.

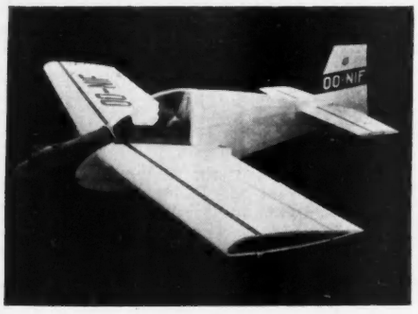
XUM

Two Westland Whirlwind helicopters for the Queen's Flight, recently handed over at Yeovil. Before now, members of the Royal Family flew in "choppers" from the RAF or one of the other Services.

The first flight of the Hiller XROE-1 Rotorcycle, built by Saunders-Roe, was made in October.

One of the most advanced helicopters flying, the twin-turbine Vertol 107 has many new features for airlines seeking safety, economy and comfort.

The first commercial operation with a Bristol 192 twin-engine, tandem-rotor helicopter took place when it "air-lifted" a large parabolic aerial.



The Tipsy Nipper, made by the Belgian subsidiary of the Fairey Group, is an ultra-light aircraft.

Weird back-to-front looking machine, the French delta-wing aircraft made by Nord-Aviation.

This Dornier Do27 light plane, handled in this country by Blackburn Aircraft, has many uses.

The Soviet IL-18 turboprop airliner, designed by Sergei Ilyushin, has four engines, each of 4,500 h.p. The machine cruises at more than 400 m.p.h.

The Lockheed Electra in the new KLM livery which does away with the Flying Dutchman wording but uses distinctive diagonal stripes on the tail.

Compressors for the Cumbrae Lighthouse

As ships slip quietly down the River Clyde on their maiden voyage, one of the first lights of the many they pass is the Cumbrae, situated near the mouth of the river.

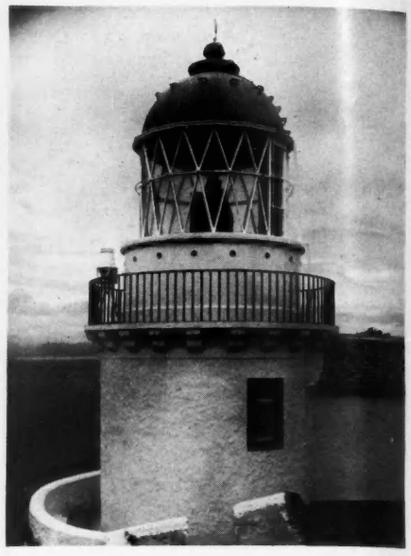
This lighthouse has recently been equipped with a new optic, pedestal, automatic power plant, fog signal and switchgear. Of this equipment (all supplied to the order of the Clyde Lighthouses Trust) the illuminant is a single 4·5 kW lamp which, intensified by the optical system, produces a beam of 1,175,000 candelas. If this lamp should fail, another automatically swings into focus and an alarm is sounded in the control room.

Each of the duplicate power plants, one of which operates automatically in the event of mains failure, consists of a Rolls-Royce diesel engine directly coupled to a McFarlane alternator and a Broom and Wade compressor. These two compressors must be completely reliable and efficient since they have to provide compressed air for the diaphone fog signal which alone indicates the position of the lighthouse to shipping when the beam cannot be seen in fog or murky weather. The importance of the task that is to be undertaken by this equipment has called for a very stringent specification to be drawn up.

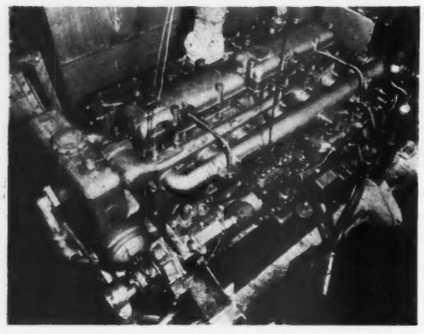
Delivering 320 c.f.m. at 100 lb per sq. in, the compressors, the only ones on this installation, are engine-driven no matter whether the mains

supply fails or not. The engine compressor sets also have alternators associated with them, so that if the engines are running to provide emergency electric current during a mains supply failure, and compressed air is required at the same time for the fog signal, the compressors are clutched in. If, on the other hand, the mains supply is sufficient and compressed air is required for the fog signal, the engine-driven compressors are run, but the alternators are not connected to the load.

The whole of this system was supplied by Stone-Chance Limited, a member firm of Stone-Platt Industries Limited. The design work was carried out in conjunction with Mr. Ritchie M. Campbell, M.I.C.E., engineer to the Clyde Lighthouses Trust.



Clyde "Puffer" Converted to Diesel Power



By replacing its steam machinery with a diesel power plant, one of the small Scottish ships (known as "puffers") has been able to reduce its operating costs. The new machinery is smaller and so the cargo hold has been extended too.

The ship is named Lascar and is one of a large fleet owned by J. and J. Hay Limited. It has been fitted with an Ajax Argosy marine propulsion unit based on a Leyland-Albion EN. 900 industrial diesel engine. This is a six-cylinder engine of 926 cu. in capacity which has a continuous rating (with standard marine equipment) of 145 b.h.p. at 1,600 r.p.m. corresponding to a b.m.e.p. of 90 lb per sq. in. Transmission is through an oil-operated reverse-reduction gear produced by Self-Changing Gears Limited, an associate company of Leyland Motors Limited. It has a 5 to 1 ratio to the propellor shaft which rotates a 54 in cast-iron propellor at 320 r.p.m. This gives the Lascar a speed of 7½ knots when fully laden with a deadweight of 180 tons.

The "puffers" are used on the River Clyde to transport coal, distillery grains, empty herring boxes, building materials and livestock between Glasgow, Clyde outports and the Western Isles. They are normally propelled by a vertical boiler with non-condensing engine. This traditional machinery is simple and robust, but the boilers do not last for ever and replacement by diesel is a cheaper proposition.

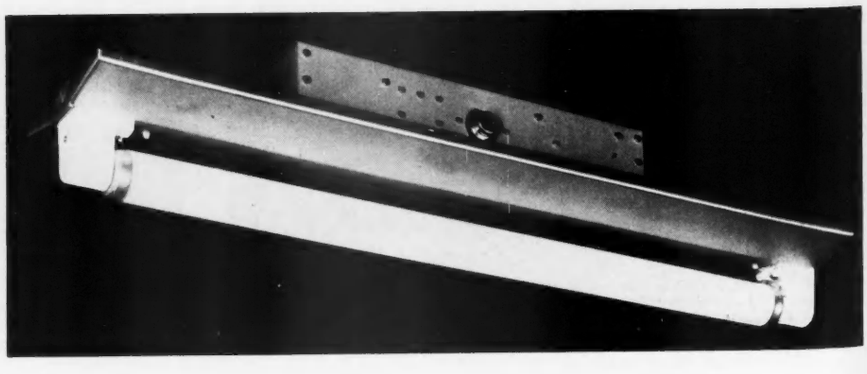
Fluorescent Lighting with Transistor Inverters

Seven first-class coaches in the five sets of vehicles forming the "Caledonian" London-Glasgow express of the London Midland Region, British Railways, have experimental fluorescent lighting in the compartments. The lighting operates on the ordinary 24 V d.c. supply from the coach batteries, and this is converted by transistor inverters to give the required operating voltage at a high frequency. It is the first time that public service vehicles have been fitted with this type of equipment.

Sixty complete sets of equipment, each consisting of a lighting fitting, transistor inverter and Osram 2 ft 20 W warm white fluorescent tube, have been designed and supplied by the General Electric Company Limited, Kingsway, London, WC2. The fitting (a trial design) consists of an anodised aluminium backplate serving as a reflector, on top of which is mounted a case containing the transistor inverter and lamp circuit equipment. The case is approximately 12 in long by 3½ in wide by 2½ in high. The two transistors are connected in a push-pull circuit with a suitable margin of safety to withstand the maximum peak inverse voltage that may occur. One transistor is mounted externally on each side of the case and in good thermal contact with it, so that the case metalwork acts as a radiator to assist heat dissipation. Windings on the transformer form the oscillatory circuit and provide the feedback to the transistors. The tuned secondary has the usual pre-heating windings and is connected to the tube through a choke. Both transformer and choke are of lightweight construction, the complete inverter unit weighing only about 3 lb.

The equipment has been designed to operate over an input voltage range of 22 to 32 volt d.c. and to ensure striking of the tubes at 0° C.

This sytem seems to have worked fairly well, for the Company is at present engaged on further contracts for the Midland and Eastern Regions and for the Pullman Car Company. These systems employ 4 ft 40 W tubes and up to four tubes are worked from one transistor inverter. The Midland Region and Pullman lighting will be worked off an input voltage of 24 to 28 volt d.c., while the Eastern Region will be off 110 volt d.c. Since the new contracts are for saloon rolling stock, it has been possible to use 4 ft tubes instead of the 2 ft tubes in the compartmented coaches of the "Caledonian."



XUM

Effect of Restoring Deformed Parts

Plastically overloaded components are sometimes restored to shape without heat treatment. This introduces residual stresses which set new limits to the elastic strengths of the parts.

By Boris N. Cole, Ph.D., Wh.Sc., A.M.I.Mech.E.

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The elastic load-carrying capacity of a machine component or structural member may be exceeded, with consequent permanent change of shape, in a variety of practical circumstances which can be grouped broadly as follows:
(*a*) damage by steady overload in a state of zero or uniform motion;
(*b*) damage due to uncontrolled vibration; and
(*c*) damage due to impact.
For a given system geometry, the damage patterns for these three cases will generally tend to be quite distinct, and no certain basis exists for direct comparison.

Frequently, damage sustained may be slight enough to be tolerated in later service; indeed, it may even be unsuspected. On the other hand, obvious damage—if not bad enough to warrant immediate scrapping and replacement of the part—is often dealt with by forcing the part as far as possible back to its original shape, and returning it to service without any form of heat treatment. Out of this procedure arises the dual question: what correcting forces are required for a given elastic-plastic deformation; and what residual stresses, affecting subsequent elastic usage, will be created within the part after it has been restored to its correct shape? It need hardly be said that the practical answer to the first part of this question is supplied by normal skilled workmanship without need for calculation, but the answer to the second part can only come from test or analysis.

While the problem posed can hardly have escaped attention altogether, there is little in published literature to which reference can be made. The following is a brief discussion of two elementary systems lying within the scope of category (*a*) above.

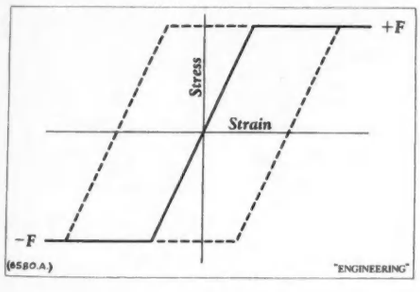
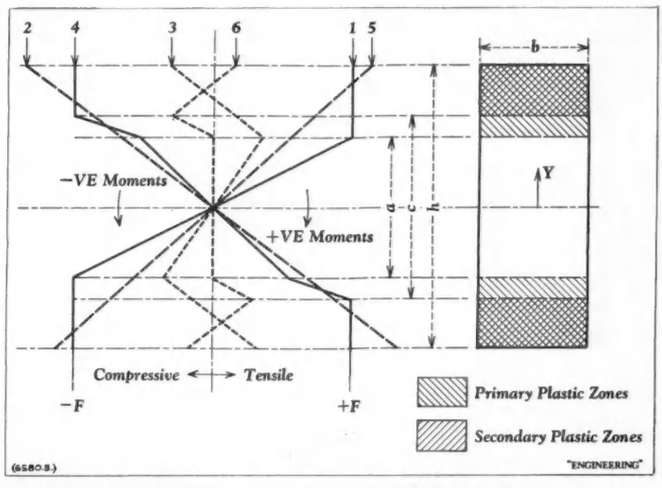


Fig. 1 (left) Stress-strain characteristics of material yielding at stress F.

Fig. 2 (right) Stress history of an over-strained beam, subsequently straightened.



It is assumed that the material is of elastic-plastic character, exhibiting a tensile yield stress of F in the uniaxial test, and yielding in general in accordance with Tresca's criterion, without work-hardening. The implications of this statement are shown in Fig. 1.

STRAIGHTENING AN OVERSTRAINED BEAM

An initially straight beam of rectangular cross-section is assumed to be overloaded by pure bending. For the given assumptions, it is readily shown that the maximum elastic bending moment, M_e, and the maximum plastic bending moment, M_y, are given respectively by:

$$\frac{M_e}{b\,F\,h^2} = \frac{1}{6} \quad . \quad . \quad . \quad (1)$$

and

$$\frac{M_p}{b\,F\,h^2} = \frac{1}{4} \quad . \quad . \quad . \quad (2)$$

where the symbols b and h are explained in Fig. 2. For present purposes, it is supposed that the initial deforming moment, M_1, lies somewhere between these prescribed critical moments.

The complete history of initial overstrain and subsequent straightening is illustrated in Fig. 2, involving six separate distributions of stress or stress change, which may be explained as follows. Trace 1 shows the stress distribution due to the initial overload moment M_1, with primary plastic zones extending to the top and bottom of the section from positions $Y = \pm\frac{a}{2}$; the dimension a representing the surviving elastic core of material. Introducing the symbol $x \equiv \frac{a}{h}$, it may be checked that:

$$\frac{M_1}{b\,F\,h^2} = \frac{1}{4}\left(1 - \frac{x^2}{3}\right). \quad . \quad . \quad . \quad (3)$$

Trace 2 shows the distribution of stress change consistent with the concept of elastic unloading of the section, due, in effect, to superposition of a moment $-M_1$. Trace 3 represents the algebraic summation of traces 1 and 2, and shows the residual stress distribution in the damaged, but now unloaded, beam. From consideration of the stress distribution over the dimension a, within which only elastic changes have occurred, it may be shown that the permanent deformation of the beam in terms of the radius of curvature, R, of the neutral surface, is given by:

$$\frac{h}{R} = \frac{F}{E}\left(\frac{2}{x} - 3 + x^2\right), \quad . \quad (4)$$

where E = Young's modulus. Trace 4 shows the effect of superimposing the necessary correcting or straightening moment M_4, which will be negative. While the beam is sustaining this moment, a certain degree of negative curvature will be present, and there will exist zones of reversed yield above and below the positions $Y = \pm\frac{c}{2}$. Trace 5 shows the distribution of stress change due to a second unloading of the beam section, by superimposing a moment $-M_4$. Trace 6 represents the algebraic summation of traces 4 and 5, and gives the final residual stress distribution in the once-more unloaded, and now re-straightened, beam. It will be noted that the condition that the beam is straight is represented by zero residual stresses over the dimension a, which throughout the process has been associated with purely elastic changes.

Full analysis of this descriptive account shows that the correcting moment M_4 is given by:

$$\frac{M_4}{b\,F\,h^2} = -\tfrac{1}{4}\left(1 + \frac{x^2 - 2y^2}{3}\right). \quad (5)$$

where $y \equiv \frac{c}{h}$; and x, as used in equation 3, is a measure of the initial deforming moment. x and y are related by:

$$y^3 - \left(\frac{2 + 3x + x^3}{2x}\right)y + 2 = 0 \quad (6)$$

It may also be shown that an exact analytical solution of equation 6, which in practice is quicker and more convenient to use than any of the customary approximate methods, is given by:

$$y = 2\sqrt{\frac{2 + 3x + x^3}{6x}}\cos\left\{\frac{5\pi - \tan^{-1}\sqrt{\frac{1}{27}\left(\frac{2 + 3x + x^3}{2x}\right)^3 - 1}}{3}\right\} \quad . \quad . \quad . \quad (7)$$

Turning now to the question of the elastic strength of the straightened beam, it is to be noted that, whereas the original positive and negative elastic moment capacities were numerically equal at the value of M_e quoted in equation 1, the present positive and negative capacities will differ numerically by virtue of the residual stresses existing at the upper and lower boundaries of the beam section. It can be shown that:

$$\text{(maximum negative elastic moment)}/b\,F\,h^2 = M_4/b\,F\,h^2 \quad . \quad . \quad . \quad (8)$$

and

$$\text{(maximum positive elastic moment)}/b\,F\,h^2 = 1/3 + M_4/b\,F\,h^2 \quad . \quad (9)$$

Curves representing the salient results of the foregoing analysis are shown in Fig. 3. It will be noticed that the beam in its final state is elastically weakened for positive moments, but strengthened for negative moments.

The loading conditions which do not, in the strict sense, produce pure bending should be recognised. To quote a simple example, a cantilever may be deformed by excessive end load. Here the appropriate linear variation of bending moment over the length of the beam may be combined with equations 3 and 4 to determine, after integration, the permanent

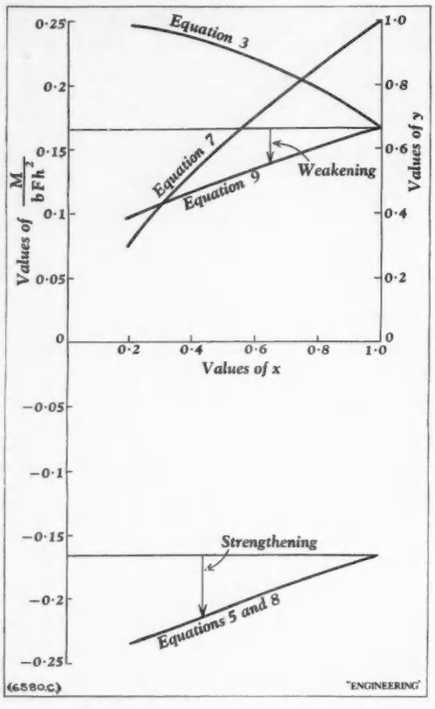


Fig. 3 (left) Elastic strength of a straightened rectangular beam. The capacity to sustain moments opposite in direction to the overstraining moment has been increased.

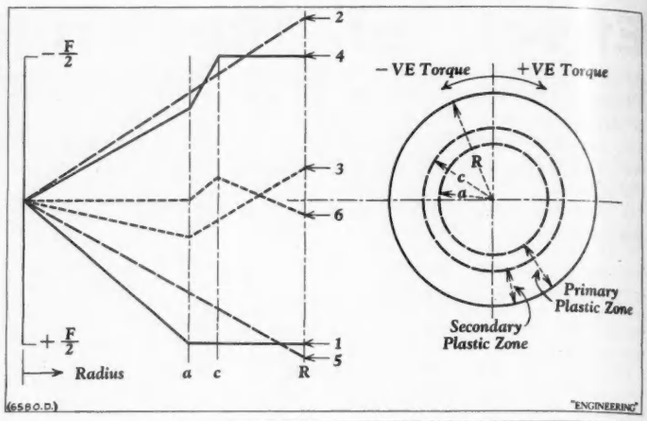


Fig. 4 (right) Stress history of an overstrained solid shaft, subsequently straightened.

deformation of the beam after removal of the end load. Any attempt to straighten the beam by simply applying an end load in a reverse direction will be frustrated because (on the basis of equations 5 and 6) the region of deformation requires a correcting-moment *versus* length distribution that cannot possibly be satisfied by the linear distribution that is actually being applied. Thus a reversed end load cannot do more than very roughly correct the initial deformation, as the simplest test confirms.

The type of argument outlined for the simple case of a rectangular beam section can be extended to deal with other, and more practical, sections and with wide plate, and need not be confined to initially straight beams. Work hardening can also be taken into account.

STRAIGHTENING AN OVER-TWISTED SHAFT

The greatest shear stress which the assumed material can withstand is equal to $\frac{F}{2}$. Hence, for a solid shaft of radius R, it is readily shown that the maximum elastic torque, T_e, and the maximum plastic torque, T_p, are given respectively by:

$$\frac{T_e}{\pi F R^3} = \frac{1}{4} \quad . \quad . \quad (10)$$

and

$$\frac{T_p}{\pi F R^3} = \frac{1}{3} \quad . \quad . \quad (11)$$

The deforming torque, T_1, will in general lie between these limits. If the ratio $\frac{a}{R}$ is denoted by x, it may be checked that:

$$\frac{T_1}{\pi F R^3} = \frac{(4 - x^3)}{12} \quad . \quad . \quad (12)$$

Fig. 4 shows the complete history of initial deformation and subsequent straightening, involving six separate distribution diagrams of stress or stress change, which are closely analogous to the six diagrams of Fig. 2 for the bending problem. The existence of this analogy makes it unnecessary to discuss Fig. 4 in detail; and the results of analysis can be given forthwith.

At the stage corresponding to trace 3 of Fig. 4, the permanent twist per unit length of shaft, θ, with the initial overload removed, is given by:

$$\theta R = \frac{F}{2G}\left(\frac{1}{x} - \frac{4}{3} + \frac{x^3}{3}\right) \quad . \quad (13)$$

where G denotes the modulus of rigidity.

The correcting torque, T_4, which, when applied and then removed, straightens the shaft and leaves no residual stresses in the elastic core of radius a, is given by:

$$\frac{T_4}{\pi F R^3} = \frac{1}{4}\left(\frac{1}{x} - \frac{2}{y}\right) \quad (14)$$

where $y \equiv \frac{c}{R}$ and is related to x in accordance with the quartic:

$$y^4 - \left(2 + \frac{x^3}{2} + \frac{3}{2x}\right)y + 3 = 0 \quad (15)$$

Functionally this expression is analogous to the cubic of equation 6 but, in the present case, the exact analytical solution is too laborious to be worth while. Instead, a solution by successive approximations is suggested, using

$$\frac{y_{n+1}}{y_n} = 1 + \frac{A\,y_n - {y_n}^4 - 3}{4\,{y_n}^4 - A\,y_n} \quad . \quad (16)$$

where $A \equiv 2 + \left(\frac{x^3}{2}\right) + \left(\frac{3}{2x}\right)$; and y_n and y_{n+1} denote respectively the nth and the $(n+1)$th approximations to the solution. For much work quite rapid convergence will follow from taking $y_1 = x$.

Finally, it can be shown that the negative and positive values of the elastic torque capacity of the re-straightened shaft are given by:

(maximum negative elastic torque)/$\pi F R^3$
$$= T_4/\pi F R^3 \quad . \quad . \quad . \quad (17)$$

and

(maximum positive elastic torque)/$\pi F R^3$
$$= \tfrac{3}{8} + T_4/2\,\pi F R_3 \quad (18)$$

Curves based on this analysis are given in Fig. 5, from which it will be seen that the shaft is elastically weakened for positive torques and strengthened for negative torques.

The treatment outlined may be extended to deal with stepped and tapered shafts, and close-coiled helical springs, and can be made to accommodate the effects of work-hardening if so desired. It could not, however, very readily be adapted to deal with shafts of non-circular section, which in any case present considerable analytical difficulties for the general elastic-plastic state.

CONCLUSIONS

While the procedure of cold-straightening an overstrained member, and returning it immediately to service, is open to criticism, the practical need is often a sufficient justification. Definite problems concerning strength then arise. For some of the simpler systems the established methods of elastic-plastic analysis can be used quite manageably to resolve these problems. Several other systems than those discussed here are capable of being more or less rigorously analysed, though some may be of more academic interest than practical value.

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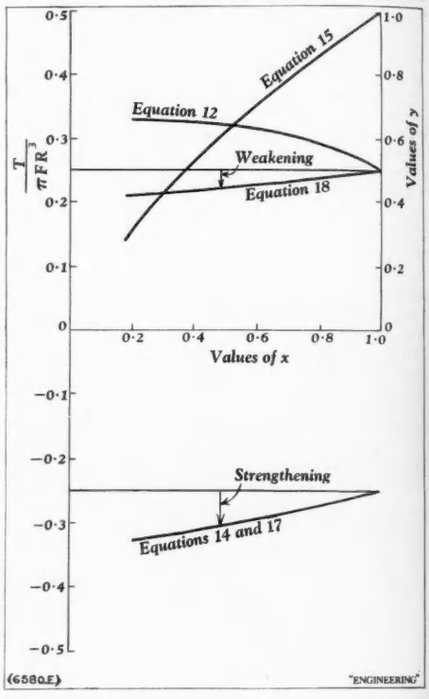

Fig. 5 Elastic strength of the straightened shaft. Its capacity to resist torques opposite in direction to the overstraining torque has been increased.

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COAL MINING WITH JETS

It was announced recently that the United States Bureau of Mines has begun experiments in mining bituminous coal by using powerful jets of water. They play a jet of water, at pressures of up to 4,000 lb per sq. in, against the coal face to break down the coal. The system resembles that used for many years in the hydraulic mining of gold.

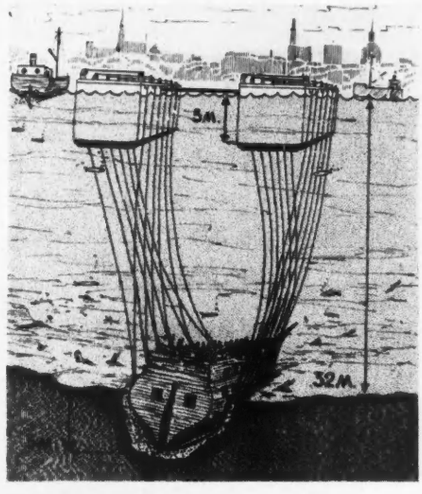
The Bureau says that the tests carried out so far have been extremely encouraging. They point out that an immediate advantage of this method is the elimination of explosive coal dust. This safety measure might be coupled with increased output—a factor which might make the method generally popular.

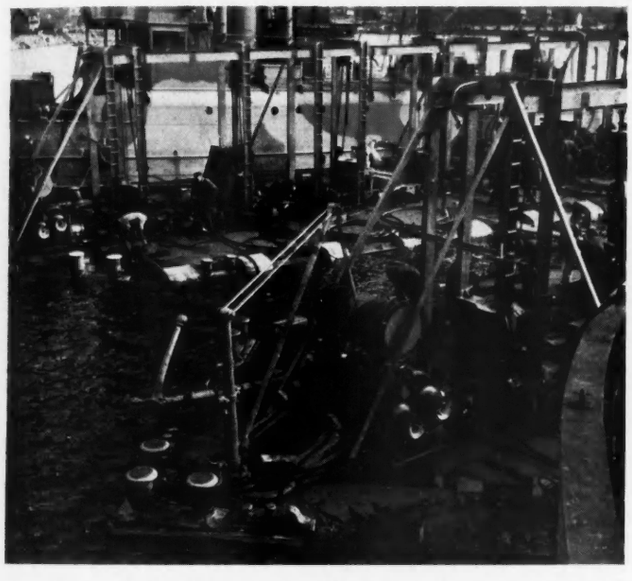
Operation and Maintenance

Naval History from the Sea Bed

Marine salvage often poses some awkward problems, and sometimes offers substantial rewards for its successful conclusion. In a salvage job at present in hand in Sweden, the problems are many and the reward will be unusual—it will provide the answer to many questions which naval historians have often asked but have so far had to try to settle without positive evidence. For the salvage work is on a Swedish warship which sank near Stockholm just 331 years ago, and has remained at a depth of 18 fathoms ever since.

Why the warship Vasa, a 44-gun three-decker ship of the line, and the pride of the Swedish fleet at the time, sank almost without warning on her maiden voyage, has never been satisfactorily explained. Perhaps the salvage, when completed, will throw some light on this problem. But even if it does not tell the reason for the disaster, it will provide a lot of information about the appearance and technical details of warships of the time. At present the oldest preserved ship in the world is Nelson's Victory, and she has by no means remained unaltered since she was built. Vasa, on the other hand, was commissioned more than a century before Victory was launched, and she has lain until now in a bed of clay, covered with silt, and mud which have protected the hull; it is certain, too, that the ship's timbers will be free from worm, as the teredo worm is not found in the Baltic.





(*Above*) *Steel cables, pontoons and much compressed air equipment are being used in the salvage of the 331 year old Swedish ship Vasa.*

(*Left*) *The scene at the surface, showing the deck equipment on the pontoons. The Vasa was raised in 17 lifts, each of about 6 ft.*

For two years the problem of raising the Vasa has been studied by divers, who have had to contend with the fact that the water in Stockholm harbour never rises above 40° F and is so clouded that the light from 200W mercury vapour lamps can only penetrate some 6 ft. Immediately the men started work and disturbed the mud, visibility dropped to zero. Consequently, the preliminary salvage work has had to be done on the basis of what the divers could feel rather than what they saw. After each shift under water each man was interrogated by naval experts, and from the various descriptions of what the men had felt as they moved about the wreck, sketches of the hull were made.

The salvage plan adopted was that of lifting the hull in stages by means of steel cables looped under it and made fast to two pontoons, one each side, which, as water ballast was pumped out, brought the hull up from the sea bed and enabled it to be towed for some distance before it bottomed again. To enable the cables to be drawn under the ship the divers cut six tunnels, each about 65 ft long. This work was carried out with the aid of compressed air equipment, provided by Atlas Copco, who have their headquarters near Stockholm.

As a result of 17 lifts by the pontoons, the Swedish Neptun Salvage Company, who are responsible for the salvage work, have moved the Vasa to a point near the shore of Kastell Holmen, the naval depot at the entrance to the inner harbour of Stockholm. Here she lies in 8 fathoms of water, having suffered no damage on the way.

Operations have now been suspended for the winter. Next spring, the divers will use high pressure air and water lines to clear the hull of the accumulated mud and silt of three centuries. This work is calculated to occupy the whole of the summer working season next year, and it will not be until 1961 that the final stage of salvage can take place. This will be the raising of the Vasa to the surface and towing her to dry dock on Kastell Holmen.

So far, more than 730 articles of all sizes have been recovered from the ship, including the figurehead, a 2 ton lion rampant, 16 ft high. The condition of this carving, and of other items brought to the surface, suggests that the timbers of the wreck are in first-class condition.

Marketing

The British in India

A reorganisation of their sales and service facilities in India has recently been carried out by the Marconi International Marine Communication Company Limited. They have concentrated their representation at Bombay where Mr. P. W. Webster, already in charge of the company's depot there, will take over general responsibility for their service depot in Calcutta. Mr. Webster becomes sole representative for India, and the day-to-day running of the Calcutta depot will be the responsibility of Mr. John Lumsden who has been promoted to the post of service manager. Marconi Marine consider that the new arrangement will materially benefit Indian shipowners and others whose vessels trade into Indian ports.

A large contract to supply four dry-seal gas holders has been placed by the Indian Atomic Energy Establishment with the Power-Gas Corporation Limited. They are being manufactured in India, special items only being supplied from the United Kingdom. A fifth gas holder for India, of 1,500 cu. ft capacity is being manufactured by one of the Power-Gas group companies, PG Engineering Limited, to an order by a British firm.

Sharples International

Developments aimed at improving the service they give to users of their products in the chemical, food and process industries have been announced recently by Sharples Centrifuges Limited. They have purchased the centrifugal division of the Fletcher Works Incorporated, United States, which will enable them to expand considerably their market potential. The American company will be known and operate as the Fletcher division of Sharples.

Another important extension of their market coverage took place when they purchased the German company Gesellschaft für Trenn-und Trockentechnik m.b.h. This purchase will also give Sharples an additional product to strengthen their own range, the "Contessor" conical screen centrifuge which has been developed by the German company. The German company's activities will continue as a division of Sharples.

Confident Contractors

The very good prospects that lie ahead for British contractors are discussed by the president of the Federation of Civil Engineering Contractors, Mr. R. M. Douglas, in an article contributed to the latest edition of the *Review of the International Federation of Building and Public Works*. Some of the statements Mr. Douglas makes suggest that the industry has good cause for facing the future with what he describes as "measured confidence." The article talks of the last budget, not of the last election, and Mr. Douglas would probably have written even more enthusiastically had he known the present Government's policy of industrial expansion would have continued undisturbed by political upheavals.

Mr. Douglas sums up the factors for continued prosperity like this: "a considerable amount of work is in prospect under the road, rail and power programmes and more local authority schemes should be coming forward. Housing is once again forging ahead and it is to be hoped that, as the policy of expansion is resumed in Britain, there will be an increase in the amount of industrial construction undertaken by industry." Clearly he expects much from the last budget's measures, and from the prevailing national confidence. There is only one cloud —which has already burst in some places—the curtailment of the open-cast coal mining programme. By and large, however, British con-

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tractors are doing very well at home, and overseas even more so. Contracts obtained have exceeded £100 million in each of the past three years, and the growth continues.

AEI marches on

Associated Electrical Industries, a week after its announcement of the tie-up with Alco, releases details of four overseas trading companies, all operative from this month in the name of AEI and carrying its integration programme a stage further.

The four are: AEI Central Africa (Private) Limited, functioning from Salisbury, Southern Rhodesia; AEI South Africa (Proprietary) Limited, at Johannesburg, South Africa; AEI (NZ) Limited, Wellington, New Zealand, and Associadas Electro-Industriais do Brasil Lda., of Rio de Janeiro, Brazil.

More Power—Less Plant

A contract to supply the first two 300 MW turbine generator units for the new West Thurrock power station has been awarded by the Central Electricity Generating Board to the Turbine-Generator Division of Associated Electrical Industries. The two machines, complete with feed water heating equipment, will cost nearly £5 million. The West Thurrock station has a planned capacity of 1,000 MW and when in full operation will consume three and a quarter million tons of coal a year.

This is a good illustration of the trend towards larger and larger units which is causing some firms in the steam generating and electrical industries so much concern. The contracts are large but few in number. The two new machines alone will have a capacity of 5,250 million units a year and their boilers will consume about two million tons of coal. This compares with 4,700 million units generated and 6½ million tons of coal consumed by the 396 steam power stations operating in 1922. The use of super-critical pressures and temperatures (inlet steam conditions are 2,300 p.s.i.g., 1,050° F, at the turbine stop valve) has introduced new standards of efficiency which have reduced substantially the amount of plant required to meet the demand for electricity, despite its continued increase.

Ploughing Champions

The news that a team of Fordson tractor and Ransomes plough has won the world ploughing contest for the sixth year in succession forces one to conclude, however reluctantly, that the days of the horse and the sturdy bullock are really over. The stiffening competition mentioned by the manufacturers relates not to a new animal challenge but to other mechanical contraptions. The choice, for this contest, of Armory—"a small, picturesque village set in the rolling countryside of County Antrim in Northern Ireland"—cannot but stir memories of these faithful beasts.

The Fordson-Ransomes success is a triumph for British agricultural engineering. The winner, Mr. W. L. McMillan, was runner up last year with the same equipment. This year second and third places go to Canadians both using Fordson tractors and Ransomes ploughs.

At Home

Informed Choice

Freedom to choose may be one of the basic liberties but it is useless if there is no yardstick by which the choice can be made.

The point is emphasised in domestic goods by the large variety of outwardly similar products now available, all apparently doing the same job but widely different in cost. One can select size, appearance, and shape, and in general it is safe to assume that a machine will do what the makers claim (if it does not there is always a legal remedy) but to judge how well it performs or whether it functions economically is impossible without extended trial or detailed performance figures. Even when such figures are available they sometimes need skilled interpretation to be of value to the layman.

There are now two bodies in this country who set out to guide the consumer in his choice of goods. They are Consumers Association Limited, an independent body, and the Consumers Advisory Council which originated in conjunction with the British Standards Institution and which still works fairly closely with that organisation. Their respective publications are *Which?* and *Shoppers' Guide*.

While both bodies set out to tell the consumer facts about various goods which he cannot see for himself, there are significant differences. In *Which?* CA give where possible a recommended "best buy." CAC confine themselves to a record of the facts of performance of the machines or quality of the goods, leaving the final deductions and choice to be made by the purchaser. Their attitude is that, if having made the facts available the consumer still chooses the red one because it matches the curtains, there can be no cause for grumbling when it does not work so well as the blue one; at least he had been warned.

Another difference is that the reports in *Shoppers' Guide* are all submitted to the manufacturers before publication; those in *Which?* are not. The reasoning behind this arrangement is that since CAC can only buy perhaps a single example of the machine there is a chance that they may get one with an individual defect. On the other hand, on at least one occasion when CA purchased a faulty item they bought a second to make sure—and it showed the same defect. Both CAC and CA buy their samples in local shops.

The business of testing the samples is a tricky one whether the goods are washing machines or detergents. As in so much experimental work, getting the right answer depends on asking the right question or at least in putting the question in the right way. Often the actual work is carried out by a specialist laboratory and their report used to compile the final published report. One such specialist establishment is Ellis Research and Testing Laboratories Limited, at Albury in Surrey. They are employed to carry out investigations and analyses for private firms and for individuals. Most of it of course is confidential but recent work has included investigations of crash helmets and roof frames, and analyses of concrete mixes.

When putting tests in hand, CAC first check against any existing British Standard for the article in question. There are comparatively few that refer to domestic goods and fewer still that cover all aspects of any one. Only in this latter event is the BS "kitemark" allotted to the goods and this then becomes their guarantee for minimum performance. In general, however, standards for domestic goods only cover one aspect, such as safety.

As a result of the tests carried out on their behalf, CAC can sometimes suggest to the BSI improvements to existing standards, or point out a line to be followed when a new standard is prepared. For example, in some recent work on oil stoves it was found that though a stove was fitted with a guard conforming in all respects to the requirements laid down in the standard, yet if a strong draught blew on the burner, flames would leap up reaching far beyond the bars of the guard. Such a draught therefore (and it was no stronger than one sometimes encountered in the grate of a three-storey house) would turn a perfectly safe heater into a lethal weapon. Should provision for this possible, but unlikely, condition be written into the standard?

To take another example from the tests on oil heaters, the Standard requires they should be capable of being tilted to an angle of 30° without falling over. At the laboratory a platform is used that is slowly tilted till the limiting angle is reached and the heater overbalances. It is then noted whether the oil spills out and also whether, if the heater was alight when it fell, the flame goes out or sets light to the spilt oil. Needless to say a fire extinguisher is kept (hopefully?) to hand.

The first tests, then, are concerned with making sure that the article conforms to any Standard which applies to it. Next comes the problem of choosing the questions so as to arrive at the facts that the consumer wants to know. As a rule these deal with efficiency, economy, and the ability of the article to do its job easily and well. It may be perfectly true, for example, to say that a vacuum cleaner has a full range of attachments that will make it the one universal tool for the whole house, but if a trained mechanic equipped with a tool chest is needed to change them, then they might as well not be there at all for all the good they will be for the housewife. Information on such points is vital when making a choice.

Cost of running is another item often omitted from sales literature. Indeed standing by itself it is not of great value, but when comparative figures are available then economies can be seen. A nice economic balance has to be made by the consumer, of first cost against running costs—one of the penalties of the privilege of free choice. When an item is only used occasionally then the running cost may not make much difference, but for such items as refrigerators and fires which may run continuously for long periods then even a small saving can quickly add up.

Few households have any member qualified to check on the claims made for some of the many chemical substances used daily in the home. In the past some advertisements have been worded very extravagantly, each trying to outdo the other. Recently a change has begun to appear, brought about by the merchandise marks requirements, by a more ethical approach by advertising agents and also in no small measure by the publication of the hard facts revealed by tests. It is little good making a shattering claim for perfection if any member of one of the consumer societies can turn up an unbiassed report disproving it.

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